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TECHNICAL UNIVERSITY OF VARNA

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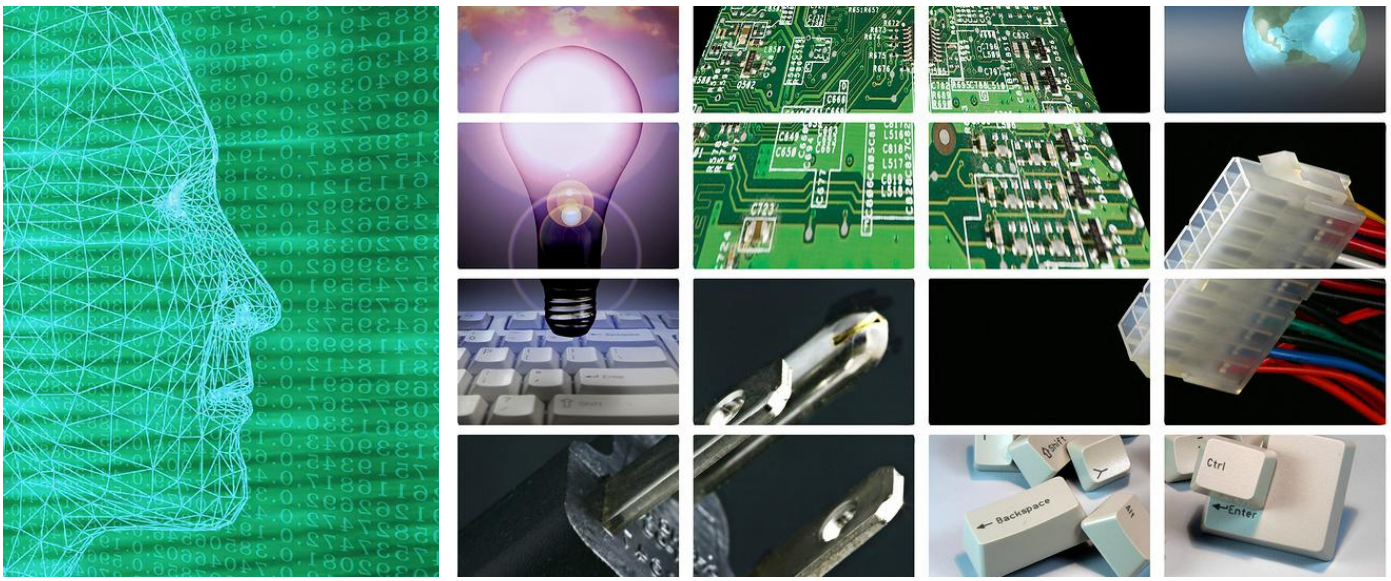

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The conference aims to provide a global forum for experts and participants from academia to exchange ideas and present results of research in the area of computer engineering and technology.

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ANALYSIS OF SOME ISSUES IN RISK ASSESSMENT FOR
INFORMATION SECURITY

CONTENT

IMPLEMENTATION OF DATA CLASSIFICATION IN BREAST CANCER PREDICTION

Ustijana Rechkoska-Shikoska

Abstract: The world is a big data problem. It contains information within that is ready to be used and implemented in solving world's every day battles. All we have to do is collect, sort out, extract the patterns in a large data set and make use of these data in order to make the right decision. This work involves the use of data mining and data classification in medicine where machines discover patterns which enable us to find the anomalies and transformations in our body cells that indicate the possibility of the most known killer - cancer. We will be targeted especially on the breast cancer since is one of the most common cancer affecting people from all over the world. The usage of the data mining techniques to find the useful data in the form of a decision tree to find the early stage of a cancer and whether it is benign or malignant is presented in this work as one of the main contributions.
Keywords: Data Mining, ID3, Data Classification, Breast cancer, Decision Tree, Pattern Recognition

1. Introduction

There are many definitions that picture the meaning and the work of data mining. Let us start with this one: "Data warehousing is a collection of decision support technologies, aimed at enabling the knowledge worker (executive, manager, analyst) to make better and faster decisions". Nowadays, with these steps taken forward in developing and innovating in every aspect of our everyday lives, especially meaning in technological point of view, we have access in an unimaginable amount of data. But, how do we make usage of these data? Most of the time the data we access to is presented in an unorganized kind of way, having many errors, anomalies, deviations most of the time. What we need to do first is "fix" this data in order to make a place for finding a pattern and find a way to make a use of this data by processing it. The term Data Mining is also generalized to any kind of computer decision support system including artificial intelligence, machine learning and business intelligence. There are multiple tasks of Data Mining that we will mention furthermore. They include: prediction methods (use some variables to predict unknown or future values of other variables); description methods (find human-interpretable patterns that describe the data); classification (predictive), clustering (descriptive), association rule discovery (descriptive), deviation detection (predictive).

The fields that data mining takes the major place in order to solve the problems that rise on everyday basis are: In creating games, business - to identify potential prospect/customers and channel/offers or market basket analysis – a data mining system could identify those customers who favor one product over another one (purchase patterns), science and engineering - data mining has been used widely in the areas of science and engineering, such as bioinformatics, genetics, medicine, education and electrical power, in the study of human genetics, data mining aims to find out how the changes in an individual's DNA sequence affects the risks of developing common diseases, visual data mining - In the process of turning from analogical into digital, large data sets have been generated, collected, and stored discovering statistical patterns, trends and information which is hidden in data, in order to build predictive patterns, pattern mining - "Pattern mining" is a data mining method that involves finding existing patterns in data. In this context patterns often means association rules. Within the analysis context, "Data mining is the process of applying artificial intelligence systems with the intention of uncovering hidden patterns". Therefore, evolution in computer science applications such as artificial neural networks, cluster analysis, genetic algorithms, support vector machines has provided additional power to data mining because

of the immediate use of the patterns discovered into the aforementioned computer science applications.

This work is done in order to help with data mining has to offer in the science of medical researches, especially those based for early discover of breast cancer and the further curing therapies that follow. What we will use is so called data mining techniques that use some of the before given tasks of data mining in order to discover the useful information needed to solve the problem.

2. Related work

Breast cancer is a type of cancer originating from the breast tissue, commonly from the inner lining of the milk ducts or lobules supplying the ducts with milk. Breast cancer occurs in both men and women, although the former type is rare. It remains the number one form of cancer that women are diagnosed with around the world. Even with enhanced treatment, the lack of early detection has put women at even higher risk of dying from this disease. [1]

By using classification of data we can accurately predict the target class for each instance in the data. This is why this task [2] is one of the most widely used in decision-making processes such in machine-based learning algorithms. In training phase of classification, each instance of the data has predefined target class. Whereas in testing phase unknown test instances are predicted using the model builds with the training set. These algorithms process a huge volume of data values and classify them based on the training set. Data preprocessing precede classification to improve the quality of the data. There are several methods of pre-processing, but whereas we consider data cleaning and data reduction techniques.

At this point, hospitals use manual cancer diagnosis system. Patients are being registered and go through radiology test process such as MRI, CT, X rays. Radiologist gives his opinion on the test report. After this process, an expert doctor reviews the X-rays/CT/MRI and gives his remarks. In some types of cancer, the diagnosis is based on the final decision by the doctors e.g. breast and lung cancer, but in other types of cancer like carcinoma some other tests are also required like biopsy. In a manual system the radiologist and the doctor diagnose cancer. This process is slow as after the radiologist's review the doctor has to review also and give remarks and finally tell if the cancer is present or not. The need is to automate this process to make the cancer diagnosis efficient and fast with the use of state of the art technology. [3]

By all of the different ways to classify data and approaches to data mining, the best prediction "tool" used is the Decision tree (with 93.62% accuracy). Accuracy on benchmark dataset (UCI machine learning dataset) and also on SEER dataset. This kind of data classifier can be used in the future to design various web based applications to accept the predictor variables and be implemented in remote areas such as rural regions or country sides, to imitate like human diagnostic expertise for prediction of ailment. [4]

We use this study to test in which areas we can use the classification based data mining techniques [5] such as Decision tree, Naïve Bayes or Rule based techniques in the healthcare. Cancer research is generally clinical and biological in nature, data driven statistical research has become a common complement. The use of these researches may lead to prediction of the outcome of a disease and this is what it makes one of the most interesting and challenging tasks where to develop data mining applications.

3. Data Mining

Data Mining is one of the most attractive "tools" of today whose implementation has the widest range and helps many branches in the information industry in recent years such as science, business management, market analysis, production control, engineering and so on.

What we do with Data Mining is simple turning any information in useful knowledge. It can be seen as a result of the natural evolution of information technology.

Data mining is a field with multiple disciplines, implementing its work in wide areas including artificial intelligence, high-performance computing, data visualization database technology, machine learning, statistics, pattern recognition, information retrieval, neural networks, knowledge-based systems and so on. In this paper, we will see data mining as a technique for the discovery of patterns hidden in large data sets, focusing on issues relating to their feasibility, usefulness, effectiveness, and scalability with respect to science, medicine and how we can implememt this in the classification of breast cancer, today's most common death cause for women from all over the world. Data mining emerged during the late 1980s, made great strides during the 1990s, and continues to flourish into the new millennium. In this work we will present firstly an overall picture of the field, introducing interesting data mining techniques and systems and discussing applications and research directions. Furthermore, we will give an explanation of how do we mine our data, what does data contain and what are the possible techniques to be used in classification of data.

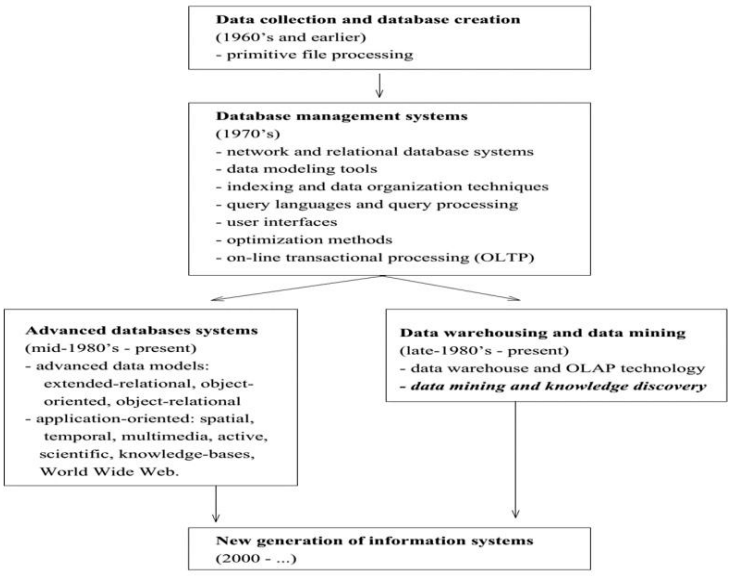

Fig. 1. The evolution of database technology; Data Mining: Concepts and Techniques Jiawei Han and Micheline Kamber Simon Fraser University 2000 (c) Morgan Kaufmann Publishers

3.1. Preprocessing of data

Before we take a step into mining of data, we need to make sure that we have preprocessed the data first. We need to get the data ready for analyze by having a closer look at attributes and data values. Real-world data are typically noisy, enormous in volume (often several gigabytes or more), and may originate from a hodgepodge of heterogeneous sources. We need to have knowledge about our data which is useful for data preprocessing, the first major task of the data mining process. We need to know what kind of attributes make up our data, which values do our attributes have, how do the data look, how is the value distributed, need to know our outliers, which data is similar to another. This is a starter pack which is must have on order to get the best knowledge of the data that we process.

An attribute is a data field, representing a characteristic or feature of a data object. We can always see the terms such as dimension (used in data warehousing), variable (statistical analysis), or feature (machine learning) also. Observed values for a given attribute are known as observations. A

set of attributes used to describe a given object is called an attribute vector. The distribution of data involving one attribute is called univariate. A bivariate distribution involves two attributes, and so on. We can determine the type of an attribute by the set of possible values—nominal, binary, ordinal, or numeric—the attribute can have. I will give some brief explanation for each of these.

The values of the nominal attribute are represented by symbols or names of things. They represent category, code, or state, and so on, but not have any meaningful order. Nominal attributes are also referred to as categorical. An ordinal attribute is an attribute with possible values that have a meaningful order or some ranking among them, but the magnitude between successive values is not known. Ordinal attributes are useful for registering subjective assessments of qualities that cannot be measured objectively; thus ordinal attributes are often used in surveys for ratings. A binary attribute is a nominal attribute with only two categories or states: 0 or 1, where 0 typically means that the attribute is absent, and 1 means that it is present. Binary attributes are referred to as Boolean if the two states correspond to true and false. When we have a numeric attribute, we have a quantitative attribute which means it is measurable, represented in real values or integers. These attributes can be interval-scaled, measured on a scale of equal-size units. They can be positive, negative or equal to 0. This provides a ranking and comparing of values. In case of ratio-scaled attributes, a true zero-point exists. That is, if a measurement is ratio-scaled, we can speak of a value as being a multiple (or ratio) of another value. In addition, the values are ordered, and we can also compute the difference between values, as well as the mean, median, and mode.

There are some other different ways to organize attribute types. These further types that we will mention are developed from the field of machine learning. Each type may be processed differently. A discrete attribute has a finite or countable infinite set of values, which may or may not be represented as integers. If an attribute is not discrete, it is continuous. Continuous attributes are typically represented as floating-point variables.

For our preprocessing of data to be successful, it is very important to have an overall picture of our data. The following statistical descriptions can be used to identify properties of the data and highlight which data values should be treated as noise or outliers.

So, we discuss the mean, median, mode, and midrange. Also, in order to find out how the data is spread out, we would like to have an idea of the dispersion of the data. The most common data dispersion measures are the range, quartiles, and interquartile range; the five-number summary and boxplots; and the variance and standard deviation of the data which are useful for identifying outliers. Finally, we can use many graphical displays of basic statistical descriptions to get a visual look in our data. These include bar charts, pie charts, line graphs, histograms, and scatter plots.

When we want to “cleanse” the large amount of data to extract the valuable part of it, to get to the knowledge, we use some “tools” in data mining in order to preprocess:

3.1.1. Aggregation

When we combine two or more attributes into a single attribute in order to make a data reduction to reduce the numbers of attributes, get more “stable” data with less variability. Data is gathered and summarized for further use, such as statistical analysis. For example, raw data can be aggregated over a given time period to provide statistics such as average, minimum, maximum, sum, and count. After the data is aggregated and written to a view or report, you can analyze the aggregated data to gain insights about particular resources or resource groups.

3.1.2. Sampling

Sampling is the main technique employed for data selection. It is often used for both the preliminary investigation of the data and the final data analysis. Sampling is used in data mining because processing the entire set of data of interest is too expensive or time consuming. The key

principle for effective sampling is the following: using a sample will work almost as well as using the entire data sets, if the sample is representative, if it has approximately the same property (of interest) as the original set of data. Sampling of data is very important since it determines the accuracy of the research and the survey result. If sample is wrong, that might result in false final results.

3.1.3. Dimensionality Reduction

In order to reduce the amount of time and memory required by data mining algorithms and allow data to be more easily visualized and reduced of noise and irrelevant features.

3.1.4. Feature subset selection

Another way to reduce dimensionality of data by duplicate much or all of the information contained in one or more other attributes.

3.1.5. Feature creation

Create new attributes that can capture the important information in a data set much more efficiently than the original attributes.

3.1.6. Attribute Transformation

A function that maps the entire set of values of a given attribute to a new set of replacement values such that each old value can be identified with one of the new values. Attribute transformation is often viewed as a simple operation that, once applied to the available dataset, can be completely ignored thereafter. The most commonly used modeling and nonmodeling attribute transformations perform simple arithmetic or logical operations, needed to adjust the data to the requirements or capabilities of some classification, regression, or clustering algorithms.

3.2. Classification of Data

We can divide the process of data classification in two steps: learning step (where we make a classification model) and a classification step (where the model is used to predict class labels for given data). Find a model for class attribute as a function of the values of other attributes. A test set is used to determine the accuracy of the model. Usually, the given data set is divided into training and test sets, with training set used to build the model and test set used to validate it. How do we start? We build a classifier describing a predetermined set of data classes with the use of an algorithm by analyzing a training set made up of database tuples and their associated class labels. In the first step, a classifier is built describing a predetermined set of data classes or concepts. This is the learning step (or training phase), where a classification algorithm builds the classifier by analyzing or "learning from" a training set made up of database tuples (samples, examples, instances, data points, or objects) and their associated class labels.

The class label attribute is discrete-valued and unordered. It is categorical (or nominal) in that each value serves as a category or class. The individual tuples making up the training set are referred to as training tuples and are randomly sampled from the database under analysis. Because the class label of each training tuple is provided, this step is also known as supervised learning (i.e., the learning of the classifier is "supervised" in that it is told to which class each training tuple belongs). It contrasts with unsupervised learning (or clustering), in which the class label of each

training tuple is not known, and the number or set of classes to be learned may not be known in advance.

This first step of the classification process can also be viewed as the learning of a mapping or function, y = f (X), that can predict the associated class label y of a given tuple X.

In this view, we wish to learn a mapping or function that separates the data classes. Typically, this mapping is represented in the form of classification rules, decision trees, or mathematical formulae. The rules can be used to categorize future data tuples, as well as provide deeper insight into the data contents. They also provide a compressed data representation.

The accuracy of a classifier on a given test set is the percentage of test set tuples that are correctly classified by the classifier. The associated class label of each test tuple is compared with the learned classifier's class prediction for that tuple. [7] [8]

4. Research of abnormal and uncontrolled cell division in breast tissue (Pathology of breast with methods in diagnostic radiology and ultrasonography)

We are living in a fast world where people rush their everyday life to keep with the pace. In this try to keep up with it, we are struggled from the stress and pressure that is built in us. This is the most common start of every process that occurs and fights our body despite all its efforts to protect us. It is well known that today's biggest "killer" is called cancer. We are trying so hard not to name this painful word, but we hear it more and more every day. It has become number one threat to people from all over the world. What I want to raise awareness for in this work is the breast cancer. This is the third deadliest cancer in the world after lung and colon cancer. Breast cancer is the most common cancer in women both in the developed and less developed world. The problem is that, in the developing countries, the most of the cases of this silent killer are diagnosed in late stages which is very crucial in order to save one's life. The prediction and diagnosing cancer in the early stages (first or second) plays the most significant role in doctor's plan to cure this fast growing murder. From our research, we found out that the most breast cancer cases are located in Europe. Countries with the highest incidence are Belgium, Denmark and France. Avoidable risk factors have been attributed to this number. Many experts claim that the westernized lifestyle has increased cancer risk. These nations have also practiced significant levels of hormonal replacement therapy in the past, the results of which are recently showing up as increased breast cancer diagnoses. These countries also have thorough mammographic screening programs that result in early detection, increased diagnoses, and higher survival rates.

The breasts of a woman are made up of fat, supportive (connective) tissue and tissues with glands called lobes. These lobes are milk glands where breast milk is produced. These are connected to the nipple by a network of milk ducts.

Both breasts may be slightly different from each other. They change throughout a woman's life and often feel different at different times in the month because of hormonal changes. Just before periods they may feel lumpy and they may feel softer, smaller and laxer as the woman ages.

Under the skin, an area of breast tissue extends into the armpit (axilla). This is called the tail of the breast. The armpits also contain a collection of lymph nodes which are part of the lymphatic system. There are also lymph nodes just beside the breastbone and behind the collarbones. These drain the breast tissues and are affected in breast diseases and inflammatory conditions. The lymph nodes are connected by a network of tiny lymphatic tubes. Lymph flows through the lymphatic system.

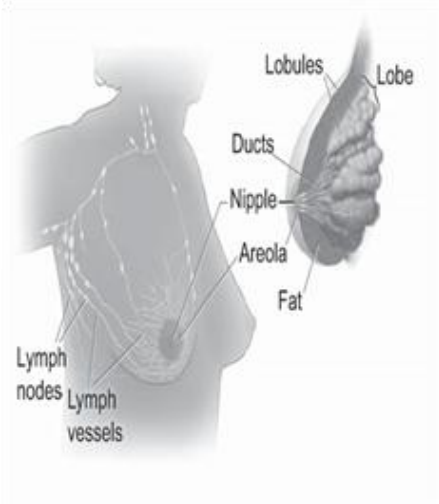

Fig. 2. Parts of a woman breast

There are trillions of cells in the body which have a regulated cell cycle that controls their growth, maturity, division and death. During childhood normal cells divide faster to allow the person to grow. Once adulthood is reached the cells divide to replace worn-out cells and to repair injuries. This cell division and growth is controlled by the cellular blue print or DNA and genes that lie within the cell's nucleus. When these cells become to "act" abnormally, start to grow out of control and create more abnormal cells, invade other tissues (metastasis) is when the cancer begins. Breast cancer is a malignant tumor that starts in the cells of the breast. Like other cancers, there are several factors that can raise the risk of getting breast cancer. Damage to the DNA and genetic mutations can lead to breast cancer have been experimentally linked to estrogen exposure. Some individuals inherit defects in the DNA and genes like the BRCA1, BRCA2 among others. Those with a family history of ovarian or breast cancer thus are at an increased risk of breast cancer.

The immune system normally seeks out cancer cells and cells with damaged DNA and destroys them. Breast cancer may be a result of failure of such an effective immune defense and surveillance.

For our discussion furthermore, taking into account medical doctors' comments explained some of the risk factors, signs of changes in the breast, how to diagnose and further possibilities to cure. The most important thing he stressed is that early detection is the most essential part in order to increase one's chances to fight off breast cancer. From the risk factors, firstly he mentioned the genetic ones (the genes brca1 brca2) stating that the risks increases from 1.7-2.5% if we have a first knee relative who fought this disease. Also, taking in account women that had their first period younger, who gave birth after their thirties or who never had children. Other factors are those that are environmental such as ways of living, as I stated at beginning stress is the silent killer, our nutrition. Those factors we cannot modify is the gender, age, breast density or family history with this illness.

Now, what are the signs that we can identify locally by self-examination: If we see that a lump has appeared within the breast. This may be a lump that is fixed to the skin above it or the chest wall and structures underlying it. The first one is more often than not a sign of cancerous tumor. Change of the skin colors, change of the size or shape of the breast or nipples, rash or sores around the nipple, discharges from the nipple. These are the local symptoms that occur most of the time and it is a sign that we must go and see a doctor.

Not every abnormal behave of the breast tissue is cancer or malign. These changes in the breast can be also benign. This means that the changes that appeared in the breast can be cists, fibro adenoma or lipoma which can occur in the young population mostly.

Speaking of the methods of diagnosis of breast cancer, we will mention Mammography as a specialized medical imaging that uses a low-dose x-ray system to see inside the breasts. A

mammography exam, called a mammogram, aids in the early detection and diagnosis of breast diseases in women.

An x-ray (radiograph) is a noninvasive medical test that helps physicians diagnose and treat medical conditions. Imaging with x-rays involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X-rays are the oldest and most frequently used form of medical imaging.

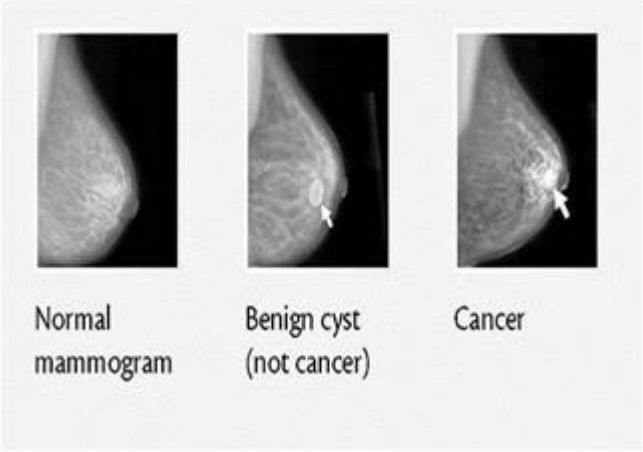

Fig. 3. Using mammography to examine abnormal cell. Here are shown scans of a normal breast, a benign mass, and cancer

Three recent advances in mammography include digital mammography, computer-aided detection and breast tomosynpaper.

Digital mammography, also called full-field digital mammography (FFDM), is a mammography system in which the x-ray film is replaced by electronics that convert x-rays into mammographic pictures of the breast. These systems are similar to those found in digital cameras and their efficiency enables better pictures with a lower radiation dose. These images of the breast are transferred to a computer for review by the radiologist and for long term storage. The patient's experience during a digital mammogram is similar to having a conventional film mammogram.

Computer-aided detection (CAD) systems search digitized mammographic images for abnormal areas of density, mass, or calcification that may indicate the presence of cancer. The CAD system highlights these areas on the images, alerting the radiologist to carefully assess this area.

Breast tomosynpaper, also called three-dimensional (3-D) mammography and digital breast tomosynpaper (DBT), is an advanced form of breast imaging where multiple images of the breast from different angles are captured and reconstructed ("synthesized") into a three-dimensional image set. In this way, 3-D breast imaging is similar to computed tomography (CT) imaging in which a series of thin "slices" are assembled together to create a 3-D reconstruction of the body.

Although the radiation dose for some breast tomosynpaper systems is slightly higher than the dosage used in standard mammography, it remains within the FDA-approved safe levels for radiation from mammograms. Some systems have doses very similar to conventional mammography.

Large population studies have shown that screening with breast tomosynpaper results in improved breast cancer detection rates and fewer "call-backs," instances where women are called back from screening for additional testing because of a potentially abnormal finding.

Breast tomosynpaper may also result in:

- earlier detection of small breast cancers that may be hidden on a conventional mammogram
- greater accuracy in pinpointing the size, shape and location of breast abnormalities
- fewer unnecessary biopsies or additional tests
- greater likelihood of detecting multiple breast tumors
- clearer images of abnormalities within dense breast tissue

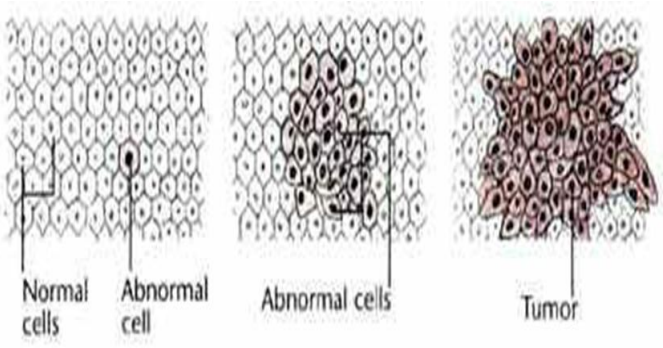

Fig. 4. Presentation of normal and abnormal cells

5. Decision Tree Algorithm

A decision tree is a technique which uses algorithms to build a decision tree, so that each node represents an attribute, each link(branch) represents a decision(rule) and each leaf represents an outcome (categorical or continues value). The topmost node in a tree is the root node. The reason is that we create a decision tree like this for the entire data and process a single outcome at every leaf (or minimize the error in every leaf). We use the decision tree for both classification and regression problems, in this work we talk about classification and how the use of decision tree may help the medicine in classification of breast cancer.

During tree construction, attribute selection measures are used to select the attribute that best partitions the tuples into distinct classes. When decision trees are built, many of the branches may reflect noise or outliers in the training data. Tree pruning attempts to identify and remove such branches, with the goal of improving classification accuracy on unseen data.

We mentioned that we use certain algorithms in order to build this. Some of the algorithms that we will briefly explain further include:

1.CART → uses Gini Index (Classification) as metric. CART stands for Classification and Regression Trees. It is characterized by the fact that it constructs binary trees, namely each internal node has exactly two outgoing edges. The splits are selected using the twoing criteria and the obtained tree is pruned by cost–complexity Pruning.

When provided, CART can consider misclassification costs in the tree induction.

It also enables users to provide prior probability distribution. An important feature of CART is its ability to generate regression trees. Regression trees are trees where their leaves predict a real number and not a class. In case of regression, CART looks for splits that minimize the prediction squared error (the least–squared deviation). The prediction in each leaf is based on the weighted mean for node.

2.ID3 (Iterative Dichotomiser 3) → uses Entropy function and Information gain as metrics.

During the late 1970s and early 1980s, J. Ross Quinlan, a researcher in machine learning, developed a decision tree algorithm known as ID3 (Iterative Dichotomiser). This work expanded on earlier work on concept learning systems, described by E. B. Hunt, J. Marin, and P. T. Stone. Quinlan later presented C4.5 (a successor of ID3), which became a benchmark to which newer supervised learning algorithms are often compared. In 1984, a group of statisticians (L. Breiman, J. Friedman, R. Olshen, and C. Stone) published the book Classification and Regression Trees (CART), which described the generation of binary decision trees. ID3 and CART were invented independently of one another at around the same time, yet follow a similar approach for learning decision trees from training tuples. These two cornerstone algorithms spawned a flurry of work on decision tree induction. ID3, C4.5, and CART adopt a greedy (i.e., non-backtracking) approach in which decision trees are constructed in a top-down recursive divide-and-conquer manner. Most algorithms for decision tree induction also follow a top-down approach, which starts with a training

set of tuples and their associated class labels. The training set is recursively partitioned into smaller subsets as the tree is being built. [9]

3.Naive Bayesian Classifiers → are statistical classifiers which can predict class membership probabilities such as the probability that a given sample will belong to a particular case. Naive Classifiers assumes that the effect of an attribute value on the given class is independent of the values of other attributes. An advantage of the naive Bayes classifier is that it requires a small amount of training data to estimate the parameters (means and variances of the variables) necessary for classification. It performs better in many complex real world situations like Spam Classification, Medical Diagnosis, and Weather forecasting. It is suited when dimensionality of input is high.

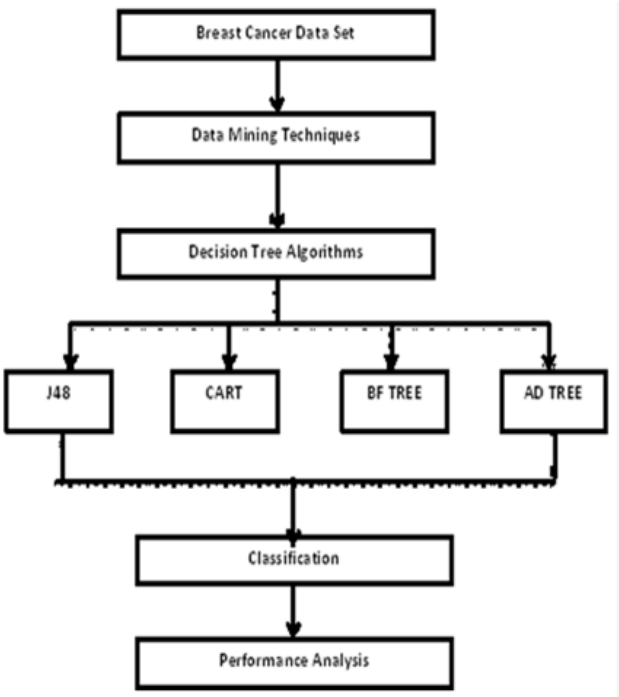

Fig. 5. Methodology, Performance Analysis of Decision Tree Algorithms for Breast Cancer Classification

5.1. An Implementation of Tree-Decision Technique in diagnosis of Breast Cancer

As we mentioned before, there are few technological ways that medicine uses to find out if a mass is benign or malignant, most commonly the mammography. Afterwards a piece of the mass is taken and examined to prove whether the mass is cancerous or not. Mammography is a process of breast examination in humans by using low-dose X-rays. With proper use, mammography can reduce mortality caused by breast cancer. Certainly, the case requires knowledge and paramedical skills in handling it. Hence, several studies have been conducted to develop computer aided breast cancer diagnosis based on digital image processing to reduce the error possibility. Naïve Bayes has several advantages, such as fast training process, unaffected by irrelevant features, and is also capable of handling real and discrete data. By combining their respective advantages, it can improve the accuracy of the classification process. To complete the identification study of breast cancer, we propose a scheme to classify breast cancer types. The classification is categorized into two types, i.e. benign and malignant. There are few medical features that we examine in order to differentiate whether a mass is malignant or benign. These include: The uniformity of cell size, which means that the growth of the cell above 2cm might aware of malignant mass, the uniformity of cell shape, in means of whether the mass is circumscribed or has irregular shape, the rate of growth, whether the mass grows slow or rapidly and if metastasis are present. These are few of the features that we use to distinct what kind of mass we work with.

5.2. ID3 Algorithm

This algorithm depicts the very basic principle of decision tree for constructing tree. It uses the divide-and-conquer strategy in the construction of decision tree, which uses the information gain of characteristic as a function of attribute selection of a branch in each node of the tree, selecting the information gain as the characteristic of the branch. ID3 algorithm is described as follows [12]:

Let E = D1 × D2 × ... × Dn be finite-dimensional vector n, where Dj is a finite set of discrete symbols, E elements e = is the sample, vj □ Dj, j = 1, 2, ..., n. Let PE be the positive sample set, NE be the anti-sample set, and the number of samples which are p and n. According to the principle of information theory, ID3 algorithm is based on two assumptions:

(1) In the vector space E, a decision tree classification probability for any sample and the probability for positive sample and anti-sample in E are the same.

(2) The expected bits of information needed for making the correct identification by a decision tree are:

$$I(p,n) = -\frac{p}{p+n}\log_2\frac{p}{p+n} - \frac{n}{p+n}\log_2\frac{n}{p+n} \tag{1}$$

If attribute A is the root of the decision tree, A has n values {u1, u2, ..., un}, which will divide the sample set E into n subsets {E1, E2, ..., En}. Supposing that Ei contains pi positive samples and ni negative samples, then a subset of the information needed for the Ei is I (pi + ni), and the expected information needed for the attribute A as the root node is:

$$E(A) = \sum_{i=1}^{n}\frac{p_i + n_i}{p+n} I(p_i + n_i) \tag{2}$$

Therefore, the information gain of classification attribute of A as the root node is Gain (A) = I (p, n)-E (A). ID3 algorithm selection contributes the greatest attribute of Gain (A) to a branch of the node attributes, and each node of the decision tree is using this principle until the decision tree is completed (each node of the samples belong to the same class or all Category attributes are used up). One advantage of ID3 is its time of tree construction and difficulty of the task (such as the number of sample set samples, the number of attributes for each sample to study the complexity of the concept of the decision tree nodes) are steadily increasing in linear and the computation is relatively small.

Steps of creating the decision tree:

Step 1: Initially calculate classification entropy.

Step 2: Select the attributes and for each attribute, calculate information gain

Step 3: Highest information gain attributes are figured out.

Step 4: Remove node attribute, for future calculation.

Repeat steps 2-4 until all attribute have been used.

Across all the domains, the performance of ID3 has resulted in good performance. Particularly, we examine its great use in medicine, especially in testing and prediction of breast cancer. This model is simple to understand and interpret, requires little data preparation, it enables to handle both numerical and categorical data, possible to validate a model using statistical tests, and most of all, it performs well with large datasets.

5.3. Advantages of decision tree

- Interpretable at a glance

- Suitable for handling both categorical and quantitative values
- Universal for solving both classification and regression problems
- Capable of handling missing values in attributes and filling them in with the most probable value
- High-performing with regard to searching down a built tree, because the tree traversal algorithm is efficient even for massive data sets

5.4. Disadvantages of decision tree

- Decision trees can be unstable. Even minor perturbations in a data set can produce a drastically different tree due to the hierarchical structure of the tree, where any modification at the top levels result in changes further down the tree.
- It can be difficult to control the size of the tree. The size of a decision tree is critical for ensuring the quality of the problem-solving process. It should be noted that decision trees may often grow to become too short or too big when you rely on simple stopping criteria.
- In some complex cases, splitting data into classes might not be helpful. Simple trees split data at nodes on a single attribute value parallel to the coordinate axes, so to say, which means that each attribute is a coordinate axis that has its own values. This leads to rectangular classification boxes that group data points corresponding to this or that class. Such partitioning may not correspond well with the actual distribution of class-specific data points in the decision space of some intricate cases.
- Information gain is prone to prefer attributes with a large number of different values. Each record may have its attribute value in extreme cases. This means that the second addend in Gain(X,A) is equal to 0, resulting in the maximum information gain.

Decision tree algorithm helps to automatically building a prediction model based on source data. We use values of source data attributes build a function that decides, evaluates, trains some model parameters by itself.

5.5. Methods and Procedures

We will do a simple discussion of how decision tree works in medical decisions and present in which way helps to decide about the possible outcome whether a mass is malignant or benign. The dataset in this discussion was taken from the hospital JZU "Dr. Svetozar Cocoroski" in Vevchani which was provided by Dr. Zharko Daskaloski, a specialist in radiology who contributes in women health and does examination on about 2000 patients yearly. His domain of work is in the west of Macedonia, Vevchani, Struga, Ohrid, Kichevo, Debar, Resen and sometimes even patients from Albania come to make a mammography or echo.

The number of breast cancer dataset provided from Dr. Daskaloski for 2018 is 1800 instances, we will create a data set consisting of 4 attributes: 1) Uniformity of cell size, 2) Uniformity of cell shape, 3) The rate of growth and 4) Presence of metastasis. We will discuss how the decision tree ID3 Algorithm works and how we make decision based on it.

We will take 50 instances, and based on the criteria we mentioned we will construct a decision tree that helps decide whether a mass is malignant or benign. We will start by doing a table and presenting the outcomes. I have created a formula that brings TRUE if there is not mistake found in the mass or FALSE if the mass shows results of cancer.

Table 1. Dataset of attributes' values, predicting benign or malignant mass in breast

Patient No.	Uniformity of cell shape	Uniformity of cell size(cm)	Rate of growth	Metastasis	Benign or Malignant
1	0	1.5	0	0	TRUE
2	1	1.8	1	0	FALSE
3	1	2.3	1	1	FALSE
4	0	1.23	0	0	TRUE
5	0	2.2	0	0	FALSE
6	0	1.96	0	0	TRUE
7	0	0	0	0	TRUE
8	0	1.97	0	0	TRUE
9	0	0	0	0	TRUE
10	0	1.64	0	0	TRUE
11	0	1.33	0	0	TRUE
12	0	0	0	0	TRUE
13	0	0	0	0	TRUE
14	0	0	0	0	TRUE
15	0	0	0	0	TRUE
16	0	0	0	0	TRUE
17	0	1.3	0	0	TRUE
18	0	0	0	0	TRUE
19	0	0	0	0	TRUE
20	0	0	0	0	TRUE
21	0	1	0	0	TRUE
22	0	0	0	0	TRUE
23	0	0	0	0	TRUE
24	0	1.78	0	0	TRUE
25	0	0	0	0	TRUE
26	0	1.1	0	0	TRUE
27	0	1.77	0	0	TRUE
28	0	0	0	0	TRUE
29	1	1.59	0	0	FALSE
30	0	2	0	0	FALSE
31	1	1	1	1	FALSE
32	0	2.6	1	0	FALSE
33	0	1.32	0	0	TRUE
34	0	1.56	0	0	TRUE
35	1	2.6	1	1	FALSE
36	1	2.13	0	0	FALSE
37	0	1	1	1	FALSE
38	1	1	1	0	FALSE
39	0	1.98	0	0	TRUE
40	1	1	1	1	FALSE
41	1	2.97	0	0	FALSE
42	0	1.24	0	0	TRUE
43	0	1.55	0	0	TRUE
44	0	1	1	1	FALSE
45	1	2.6	0	0	FALSE
46	0	1	1	1	FALSE
47	1	3	0	0	FALSE
48	1	1	1	1	FALSE
49	1	2.14	1	0	FALSE
50	0	0.89	0	0	TRUE
					31= TRUE ; 19= FALSE
					Probability of benign tumor
					0.62
					Probability of malignant tumor
					0.38

First, we number each patient. We create column for each four attributes and at the end we make a column that returns outcome TRUE or FALSE, bu using AND formula on excel (=AND (B2=0,C2<2,D2=0,E2=0)). We enter values in each column, 0 or 1 except for the second where we input the actual measure of the mass. For the first column, uniformity of cell shape, 0 means that there is not mistake found in mass and that is regular or 1 means that the shape of the mass is irregular. We continue on the second. We input the values of the mass size. Benign tumors have mass below 2cm. Each value above this size aware that a malignant cell is present and we make further examination on that mass. On the column rate of growth, 0 means that the mass is growing slow or 1 meaning that cells are growing rapid which suggests on further examination. And as last, metastasis column shows whether a metastasis is present or not. Presence of metastasis indicates of

a malignant tumor, and this is usually typical for deeper stages of cancer. This means that each case of value 1 in metastasis indicates on cancer.

The core algorithm for building decision trees called ID3 by J. R. Quinlan which employs a top-down, greedy search through the space of possible branches with no backtracking. ID3 uses Entropy and Information Gain to construct a decision tree.

5.5.1. Entropy

A decision tree is built top-down from a root node and involves partitioning the data into subsets that contain instances with similar values (homogenous). ID3 algorithm uses entropy to calculate the homogeneity of a sample. If the sample is completely homogeneous the entropy is zero and if the sample is an equally divided it has entropy of one.

Since we are working with ID3 algorithm in order to construct the decision tree, we need to figure out which attribute to choose, the algorithm has to calculate the entropy. The entropy indicates how ordered the elements are where an entropy of 1 means totally randomly and 0 means perfectly classified. With this entropy, the algorithm can calculate the information gain of the attribute, where the higher the better. After the information gain is calculated for every attribute, the attribute with the highest information gain will be placed as the root node of the decision tree. Here we have calculated the entropy first. The formula for calculating is Entropy (Decision) = – p (True) . $\log_2$p (True) – p (False) . $\log_2$p (False)

In our example we got 50 instances, out of which 31 are True and 19 are False. Here is the Entropy calculated:

Entropy(Decision)= -(31/50)*LOG2(31/50)-(19/50)*LOG2(19/50)
-0.689659879 31/50log
-1.395928676 19/50log
-0.427589125 log*31/50
-0.530452897 log*19/50
Entropy(Decision)= 0.102863772

(3)

Further, we need to find the most dominant factor for decisioning. We have started with the Metastasis attribute.

Gain(Decision,Metastasis)= Entropy(Decision)–∑[p(Decision|Metastasis).
Entropy(Decision|Metastasis)] (4)

Metastasis attribute has two labels: 0 indicating absence of metastasis and 1 indicating the presence of metastasis. We would reflect it to the formula:

Gain(Decision,Metastasis)= Entropy(Decision)–
[p(Decision|Metastasis=Absent).Entropy(Decision|Metastasis=Absent)] –
[p(Decision|Metastasis=Present) .Entropy(Decision|Metasis=Present)] (5)

Now, we need to calculate (Decision|Metastasis=Absent) and (Decision|Metastasis=Present) respectively. Here are the results:

Entropy(Decision|Metastasis=Absent)
Entropy Dec=-(11/42)*LOG2(11/42)-(31/42)*LOG2(31/42)= **0.82962**

Entropy(Decision|Metastasis=Present)
Entropy Dec=-(8/8)*LOG2(8/8)-
(0/8)*LOG2(0/8)=**0** (6)

We apply this similar calculation on the other columns:

Gain(Decision,Rate-of-Growth)= Entropy(Decision)–∑[p(Decision|Rate-of-Growth). Entropy(Decision|Rate-of-Growth)] (7)

This attribute has also two labels: 0 indicating slow rate of growth and 1 indicating rapid rate of growth. We would reflect it to the formula:

Gain(Decision,Rate-of-Growth)= Entropy(Decision)–[p(Decision|Rate-of-Growth=Slow).Entropy(Decision|Rate-of-Growth=Slow)] –[p(Decision|Rate-of-Growth=Rapid) Entropy(Decision|Rate-of-Growth=Rapid)] (8)

Entropy(Decision|Rate of Growth=Slow)
Entropy Dec=-(7/38)*log2(7/38)-(31/38)*log2(31/38)= **0.20994**
Entropy(Decision|Rate of Growth=Rapid)

Entropy Dec=-(12/12)*log2(12/12)-(0/12)*log2(0/12)=**0**

Gain(Uniformity-of-CellSize)= Entropy(Decision)–∑[p(Decision| Uniformity-of-Cell-Size). Entropy(Decision| Uniformity-of-Cell-Size)] (9)

Two labels: 0 indicating size of a mass less than 2cm, and 1 indicating a size of a mass equal or larger than 2cm. We reflect it to the formula:

Gain(Decision,Uniformity-of-Cell-Size)= Entropy(Decision)–[p(Decision| Uniformity-of-Cell-Size<2cm).Entropy(Decision|Uniformity-of-Cell-Size<2cm)] –[p(Decision|Uniformity-of-Cell-Size=>2cm).Entropy(Decision|Uniformity-of-Cell-Size=>2cm)] (10)

Entropy (Decision|Cell Size<2cm)
Entropy Dec=-(8/40)*log2(8/40)-(31/40)*log2(31/40)=**0.17939**
Entropy (Decision|Cell Size=>2cm)

Entropy Dec=-(10/10)*log2(10/10)-(0/10)*log2(0/10)=**0**

Gain(Uniformity-of-Cell-Shape)= Entropy(Decision)–∑[p(Decision|Uniformity-of-Cell-Shape). Entropy(Decision| Uniformity-of-Cell-Shape)] (11)

Two labels: 0 indicating regular shape of cells and 1 indicating irregular shale of cells. We would reflect it to the formula:

Gain(Decision,Uniformity-of-Cell-Shape)= Entropy(Decision)–[p(Decision| Uniformity-of-Cell-Shape=Regular).Entropy(Decision|Uniformity-of-Cell-Shape=Regular)] –[p(Decision|UniformityofCellShape=Irregular).Entropy(Decision|Uniformity-of-Cell-Shape=Irregular)] (12)

Entropy (Decision|Cell Shape=Irregular)
Entropy Dec=-(13/13)*log2(13/13)-(0/13)*log2(0/13)=**0**
Entropy (Decision|Cell Shape=Regular)
Entropy Dec=-(6/37)*log2(6/37)-(31/37)*log2(31/37)=**0.085757** (13)

Table 2. Metastasis, Cell shape, Cell size, Rate of growth

1.Metastasis	0.594
2.Cell Shape	0.531
3.Cell Size	0.066
4.Rate of Growth	0.056

Metastasis	50	
Present	8	0.16
Absent	42	0.84
Rate of growth	50	
Slow	38	0.76
Rapid	12	0.24
Cell size	50	
>=2	8	0.16
<2	42	0.84
Cell shape	50	
Irregular	13	0.26
Regular	37	0.74

Now we compare results and as seen, metastasis factor on decision produces the highest score. That's why, metastasis decision will appear in the root node of the tree. We implement the similar steps for the sub nodes. We get to the following decision tree:

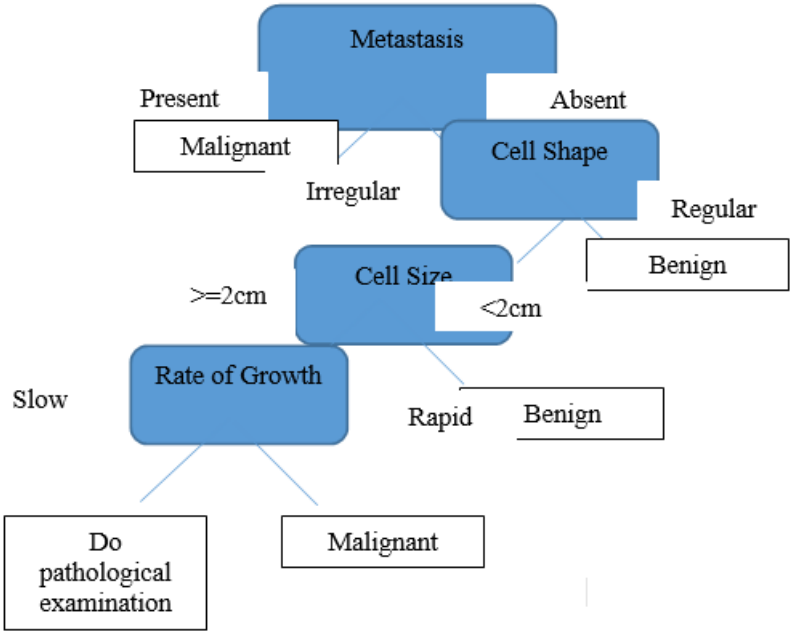

Fig. 7. Decision tree using ID3, implementing our testing, formula and calculations to build this Decision Tree and depict our research. As attribute with the greatest dominant factor for decisioning- Metastasis, we create the root node. Dividing the sub nodes procedure is similar to the previous and result is as presented above

6. Conclusion

We make different kind of decisions every day. Our brain takes in account each possible outcome before we do something. Decision tree algorithms work in this similar way. Calculating every possibility, entropies, gains. In our discussion we have shown a very simple example how would data classification and organization of data can help medicine improve people's health and life using simple data tree. Breast cancer becomes top one "killer" nowadays. What is even more terrifying the age target that is concerned with this merciless sickness each year decreases and the population that fights with it is even younger and younger. From the statistics that we have looked at, every year the number of patients with breast cancer diagnosis is rising. This is my chance to

aware all the women out there to take control of their health and do mammography and echo examinations regularly because in cases with cancer the stage we discover the malignant mass is very important to continue one's life. The earliest we find this silent killer the bigger are the rates to survive.

7. Future Work

We are very determined to keep up doing this work and find different ways of implementing data classification and decision tree algorithms further and contribute into saving women's lives. Our future work would include implementing this work into algorithms and make additional software solutions that would be using more attributes and get more precise results that prevents growth of malignant cells. This work included pretty much simple data and calculations. We would expand data in the future work and implement attributes such as hormone receptors (ER, PR) и HER2 статусот (HER2 - Human Epidermal growth factor Receptor 2), and brca1 and brca2, breast cancer gene examination.

Furthermore, we plan to implement deep learning knowledge and to use security methods, do an implementation of the deep learning results and do evaluation referring to the gained feedback.

Acknowledgement

The acknowledgement for the medical research issues of this work goes to the hospital JZU "Dr. Svetozar Cocoroski" in Vevchani, to Medical Doctor Zharko Daskaloski, a specialist in Radiology who contributes in women health and does examination on about 2000 patients yearly. Dr. Daskaloski domain of work is mostly in the west of Macedonia, Vevchani, Struga, Ohrid, Kichevo, Debar, Resen and also with patients from Albania, referring a mammography or echo. It also goes to Miss Jana Radinoska, who has great interest in imlementing Data Classification methods and helped out in this research.

References

[1]. International Journal of Computer Applications (0975 – 8887) Volume 98– No.10, July 2014.
[2]. International Journal of Current Pharmaceutical Research ISSN- 0975-7066 Vol 9, Issue 2, 2017.
[3]. Published at: https://www.researchgate.net/publication/267636320 Cancer diagnosis using data mining technology Article in Life Science Journal · September 2012 author: Dr Syed Athar Masoo
[4]. International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Vol.2, No.2, April 2012.
[5]. Jaimini Majali et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (5), 2014, 6487-6490: Data Mining Techniques For Diagnosis And Prognosis Of Breast Cancer.
[6]. Data Mining:Concepts and Techniques Second Edition Jiawei Han and Micheline Kamber University of Illinois at Urbana-Champaign, 2006.
[7]. Data Mining Concepts and Techniques Third Edition Jiawei Han University of Illinois at Urbana–Champaign Micheline Kamber Jian Pei Simon Fraser University, 2012.
[8]. http://dataaspirant.com/2017/01/30/how-decision-tree-algorithm-works/
[9]. Abbas Rizvi,CS157 B, Spring 2010.
[10]. L.Surya Prasanthi et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (6), 2015, 5353-5357.
[11]. Ruijuan Hu,(2011),' Medical Data Mining Based on Decision Tree Algorithm', Computer and Information Science,Vol. 4, No. 5; September 2011, www.ccsenet.org/cis.

[12]. Kantardzic M. (2002). Data Mining Concept, Models, Methods and Algorithms. IEEE Press.

DESIGN OPTIMIZATION OF 200 AMPS BOOSTER TRANSFORMER BASED ON DIFFERENTIAL EVOLUTION ALGORITHM

Rasim Salkoski, Ile Dimitrievski

Abstract: The optimization techniques used in the design of the booster transformer result in saving of supply electric energy for the railway power supply systems. The feed arrangement is single-phase and only has one feed (reference bus). The loads are electric locomotives, can move along the rail tracks and locomotives can be added into the system or be removed from the system at any instance. Special interest is given to the minimization of production and exploitation costs of the booster transformer. The booster transformer is connected to the catenary and rail, and consist of a transformer with equal number of turns on each winding. The optimization algorithm based on Differential Evolution is applied to the problem of minimizing the cost of the active parts of the booster transformer. All constraints are normalized and modeled as inequalities.
Keywords: Booster Transformer, Evolutionary algorithms, Optimization techniques, Railway, Differential Evolution Algorithm

1. Introduction

Since high performance computers have been developed, within a matter of minutes or even seconds, computers can generate a number of different booster transformer designs (by changing current density, flux density, core dimensions, type of magnetic material and so on) and eventually come up with an optimal design. The difficulty in resolving the optimum balance between the cost of booster transformer and its performance is becoming even more complicated nowadays, as the main materials to produce (copper or aluminum for transformer windings and steel for magnetic circuit) are stock exchange commodities and their prices vary daily. Techniques that include mathematical models containing analytical formulas, based on design constants and approximations for the calculation of the booster transformer parameters are often the base of the design process used by manufacturers. Evolutionary algorithms and all their variants have been extensively used for solving combinatorial optimization problems. One area of great importance that can benefit from the effectiveness of such algorithms is AC railway power supply systems. The work in this paper introduces the use of an evolutionary algorithm, titled Differential Evolution (DE) in conjunction with the penalty function approach to minimize the booster transformer cost while meeting international standards and customer needs. A simple additive penalty function approach is used in order to convert the constrained problem into an unconstrained problem. Due to this conversion, the solution falling outside the feasible region is penalized and the solving process is guided to fall into the feasible solution space after a few generations. The method of penalty function approach is very sensitive when the penalty parameters are large. Penalty functions tend to be very sensitive near the boundary of the feasible domain and that result in a local optimal solution or an infeasible solution. It is always necessary to have careful selection of the penalty parameters for the proper convergence to a feasible optimal solution.

The method is applied to the design of a booster transformer and the results are compared with a heuristic transformer design optimization methodology, resulting in significant cost savings.

2. Related work

In this paper the Penalty Function method is implemented to handle the constraint using the Differential Evolution (DE) algorithm. Other authors have proposed different approaches to solve constrained optimization with DE-based algorithms.

B. V. Babu and M. Mathew Leenus Jehan in [7] have applied Differential Evolution with a Penalty Function Method and Weighting Factor Method for finding a Pareto optimum set for the different problems. DE is found to be robust and faster in optimization. DE managed to give the exact optimum value within less generations compared to a simple Genetic Algorithm. Mezura-Montes and Coello Coello in [11] present a Differential-Evolution based approach to solve constrained optimization problems. Three selection criteria based on feasibility are used to deal with the constraints of the problem and also a diversity mechanism is added to maintain infeasible solutions located in promising areas of the search space. The conventional DE algorithm highly depends on the chosen trial vector generation strategy and associated parameter values used. DE researchers have suggested many empirical guides for choosing trial vector generation.

Storn and Price [10] suggested that a reasonable value for NP should be between 5D and 10D, and a good initial choice of F was 0.5. The effective range of F values was suggested between 0.4 and 1. The first reasonable attempt of choosing CR value can be 0.1. However, because the large CR value can speed up convergence, the value of 0.9 for CR may also be a good initial choice if the problem is near unimodal or fast convergence is desired. Moreover, if the population converges prematurely, either F or NP can be increased.

Recently, Rönkkönen in [13] suggested using F values between [0.4,0.95] with 0.9 being a good initial choice. The CR values should lie in [0,0.2] when the function is separable while in [0.9,1] when the function's parameters are dependent. However, when solving a real engineering problem, the characteristics of the problem are usually unknown. Hence, it is difficult to choose the appropriate CR value in advance.

The researchers have developed some techniques to avoid manual tuning of the control parameters. For example, linearly reduced the scaling factor F with increasing generation count from a maximum to a minimum value, or randomly varied F in the range (0.5,1). They also have employed a uniform distribution between 0.5 and 1.5 (with a mean value of 1) to obtain a new hybrid DE variant.

3. The Differential Evolution (DE) Algorithm

Differential Evolution (DE) algorithm is a population-based stochastic method for global optimization developed by Rainer Storn and Kenneth Price [10] for optimization problems over continuous domains. The original version of DE with constituents can be defined as follows : This template was designed for two affiliations.

1) The population

$$\begin{aligned} &P_{\boldsymbol{x},g} = \left(\boldsymbol{x}_{i,g}\right),\ \ i = 0,1,.....,NP,\ g = 0,1,.....,g_{max} \\ &\boldsymbol{x}_{i,g} = \left(x_{j,i,g}\right),\ j = 0,1,.....,D-1. \end{aligned} \tag{1}$$

where *NP* is the number of population vectors, *g* defines the generation counter, and *D* the number of parameters.

2) The initialization of the population through

$$x_{j,i,0} = rand_j\left[0,1\right)\cdot\left(b_{j,U} - b_{j,L}\right) + b_{j,L}\ . \tag{2}$$

The D-dimensional initialization vectors, $\boldsymbol{b}_L$ and $\boldsymbol{b}_U$ indicate the lower and upper bounds of the parameter vectors $\boldsymbol{x}_{i,j}$. The random number generator, $rand_j[0,1)$, re-turns a uniformly distributed random number from within the range [0,1), i.e., $0 \leq rand_j[0,1) < 1$. Indication that a new random value is generated for each parameter is denoted by the subscript j. This template was designed for two affiliations.

3) The pertubation of a base vector $\boldsymbol{y}_{i,g}$ by using a difference vector mutation

$$\boldsymbol{v}_{i,g} = \boldsymbol{y}_{i,g} + F \cdot \left(\boldsymbol{x}_{r1,g} - \boldsymbol{x}_{r2,g} \right). \tag{3}$$

to generate mutation vector $v_{i,g}$. The difference vector indices, r_1 and r_2, are randomly selected once per base vector. Setting $y_{i,g} = x_{r0,g}$ defines what is often called classic DE where the base vector is also a randomly chosen population vector. The random indexes r_0, r_1, and r_2 should be mutually exclusive. This template was designed for two affiliations.

4) Diversity enhancement

The classic variant of diversity enhancement is crossover which mixes parameters of the mutation vector $\boldsymbol{v}_{i,g}$ and the so-called **target vector** $\boldsymbol{x}_{i,g}$ in order to generate the **trial vector** $\boldsymbol{u}_{i,g}$. The most common form of crossover is uniform and is defined as

$$\boldsymbol{u}_{i,g} = u_{j,i,g} = \begin{cases} v_{j,i,g} \ \ if \left(rand_j [0,1) \leq CR \right) \\ x_{j,i,g} \ otherwise \end{cases} \tag{4}$$

In order to prevent the case $\boldsymbol{u}_{i,g} = \boldsymbol{x}_{i,g}$ at least one component is taken from the mutation vector $\boldsymbol{v}_{i,g}$, a detail that is not expressed in (4). This template was designed for two affiliations.

5) Selection

DE uses simple one-to-one survivor selection where the trial vector $u_{i,g}$ competes against the target vector $x_{i,g}$. The vector with the lowest objective function value survives into the next generation $g + 1$.

$$\boldsymbol{x}_{i,g+1} = \begin{cases} \boldsymbol{u}_{i,g} \ \ if \ \ f\left(\boldsymbol{u}_{i,g} \right) \leq f\left(\boldsymbol{x}_{i,g} \right) \\ \boldsymbol{x}_{i,g} \ otherwise. \end{cases} \tag{5}$$

Along with the DE algorithm came a notation (5) to classify the various DE-variants. The notation is defined by DE/*x*/*y*/*z* where *x* denotes the base vector, *y* denotes the number of difference vectors used, and *z* representing the crossover method. For ex-ample, DE/rand/1/bin is the shorthand notation for (1) through (5) with $y_{i,g} = x_{r0,g}$. DE/best/1/bin is the same except for $y_{i,g} = x_{best,g}$. In this case $x_{best,g}$ represents the vector with the lowest objective function value evaluated so far.

With today's extensions of DE the shorthand notation DE/*x*/*y*/*z* is not sufficient any more, but a more appropriate notation has not been defined yet.

Price and Storn [10] gave the working principle of DE with single strategy. They suggested ten different strategies for DE. Different strategies can be adopted in the DE algorithm depending upon the type of problem to which DE is applied. The strategies can vary based on the vector to be perturbed, number of difference vectors considered for perturbation, and finally the type of crossover used. The following are the ten different working strategies: 1. DE/best/1/exp, 2. DE/rand/1/exp, 3. DE/rand-to-best/1/exp, 4. DE/best/2/exp, 5. DE/rand/2/exp, 6. DE/best/1/bin, 7. DE/rand/1/bin, 8. DE/rand-to-best/1/bin, 9. DE/best/2/bin, 10. DE/rand/2/bin.

As it is explained the general convention used above is DE/*x*/*y*/*z*. DE stands for Differential Evolution, *x* represents a string denoting the vector to be perturbed, *y* is the number of difference vectors considered for perturbation of *x*, and *z* stands for the type of crossover being used (exp: exponential; bin: binomial). Hence the perturbation can be either in the best vector of the previous

generation or in any randomly chosen vector. Similarly for perturbation either single or two vector differences can be used. For perturbation with a single vector difference, out of the three distinct randomly chosen vectors, the weighted vector differential of any two vectors is added to the third one. In exponential crossover, the crossover is performed on the D variables in one loop until it is within the CR bound. The first time a randomly picked number between 0 and 1 goes beyond the CR value, no crossover is performed and the remaining D variables are left intact. In binomial crossover, the crossover is performed on each of the D variables whenever a randomly picked number between 0 and 1 is within the CR value. So for high values of CR, the exponential and binomial crossover methods yield similar results.

A strategy that works out to be the best for a given problem may not work well when applied to a different problem. Also, the strategy and the key parameters to be adopted for a problem are to be determined by trial and error. However, strategy-7 (DE/rand/1/bin) appears to be the most successful and the most widely used strategy. In all, three factors control evolution under DE, the population size NP, the weight applied to the random differential F and the crossover constant CR.

4. Booster Transformer

The booster transformer is connected to the catenary and rail as in **Fig.1**. It consist of a transformer with equal number of turns on each winding, forcing the current through the catenary and the return circuit to be equal. The main purpose of the Booster Transformer-system is to minimize the leakage current through the ground.

In countries or areas where earth resistivity is high, booster transformers are used to make sure that the same current level that passes through the contact line also goes back through the return conductor. This is done in order to reduce the rail potential and disturbances to telecommunication systems and other electrical equipment. In some parts of the world, booster transformers are not needed.

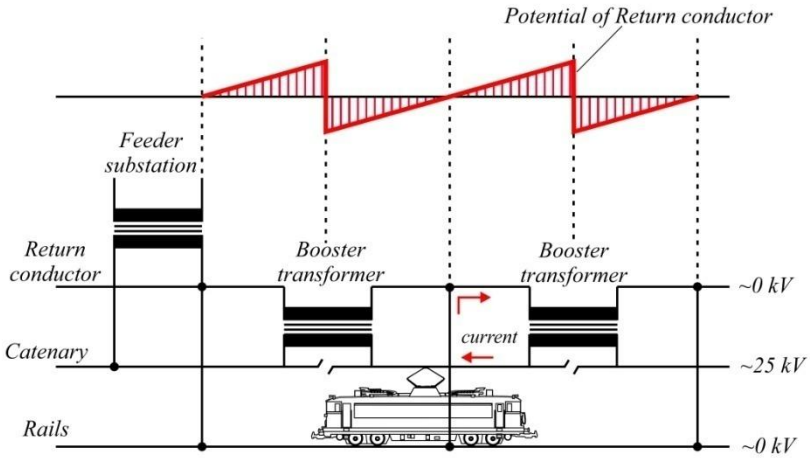

Fig. 1. Overhead catenary booster transformer feeding configuration

4. Mathematical Modelling and Optimization of Booster Transformer for Single-Phase AC Railway Feeding Systems

A mathematical description of a global constrained minimization problem requires us to apply an appropriate model which has limited number of parameters (design variables). Any kind of

optimization problem can be formalized to find the appropriate set of design variables in the multidimensional parameter space, which can optimize the main objective function. In the mathematical notation the optimization problem can generally be represented as a pair (S, f), where $S \subseteq R^n$ is a bounded set on R^n and $f : S \rightarrow R$ is an n-dimensional real-valued function. The problem is to find a point $\boldsymbol{x}_{min} \in S$ such that $f(\boldsymbol{x}_{min})$ is a global minimum on S. More specifically, it is required to find an xmin $\in S$ such that

$$\forall \boldsymbol{x} \in S : f(\boldsymbol{x}_{min}) \leq f(\boldsymbol{x}) \tag{6}$$

$$g_i(\boldsymbol{x}) \leq 0,\ i = 1, 2, \bullet\bullet\bullet, q \tag{7}$$

$$h_j(\boldsymbol{x}) = 0,\ j = q + 1, \bullet\bullet\bullet, m \tag{8}$$

where $\boldsymbol{x} = [x_1, x_2, \bullet\bullet\bullet, x_n]^T$ is the vector of unknown quantities, $g_i(\boldsymbol{x})$ and $h_j(\boldsymbol{x})$ are the restriction constraints, which can be represented mathematically as equations and/or inequations, m and q are integer numbers. Generally, for each variable x_i it satisfies a constrained boundary

$$l_i \leq x_i \leq u_i,\ i = 1, 2, \bullet\bullet\bullet, n \tag{9}$$

In order to find the global optimum design of an arc suppression coil, DE in conjunction with the penalty function approach technique is used. The goal of the proposed optimization method is to find a set of integer variables linked to a set of continuous variables that minimize the objective function (active part cost) and meet the restrictions imposed on the booster transformer. Under these definitions, a DE algorithm in conjunction with the penalty function approach is focused on the minimization of the cost of the booster transformer:

$$\min_{\boldsymbol{x}} \sum_{j=1}^{2} c_j \cdot f_j(\boldsymbol{x}) \tag{10}$$

where c_1 is the winding unit cost (€/kg), f_1 is the winding weight (kg), c_2 is the magnetic material unit cost (€/kg), f_2 is the magnetic material weight (kg), and $\boldsymbol{x}$ is the vector of the five design variables, namely the width winding (a), the diameter of core leg (D), the winding height (b), the current density of winding (g) and the magnetic flux density (B).

The minimization of the cost of the booster transformer is subject to the constraints:

$$S - S_N \leq 0;\ P_{CU} - P_{CUN} \leq 0;\ P_{FE} - P_{FEN} \leq 0;\ Z_{TOT} - Z_{TOTN} \leq 0$$

where: S is designed booster transformer rating (kVA), S_N is booster transformer nominal rating (kVA), P_{FE} is designed no-load losses (W), P_{CU} is designed load losses (W), Z_{TOT} is designed impedance of booster transformer secondary side (Ohms), P_{FEN} is guaranteed no-load losses (W), P_{CUN} is guaranteed load losses (W) and Z_{TOTN} is guaranteed impedance of booster transformer secondary side (Ohms).

It should be noted that functions f_1, f_2, appearing in the objective function (10) are composite functions of the design variables $\boldsymbol{x}$, e.g., $f_1 = f_1(g_1(h_1(\boldsymbol{x})))$ the booster transformer design optimization problem is a hard problem in terms of both modeling and solving.

The single objective Differential Evolution optimization algorithm with penalty function approach has been applied. Accordingly, the objective function for the model is:

$$\begin{aligned} f(x_2, x_3, x_5) = &\left(2.10 \cdot 10^4 \cdot x_5 + 1.60 \cdot 10^5 \cdot x_3 + 2.04 \cdot 10^3\right) \cdot x_2^2 + \\ &1.38 \cdot x_2^3 + \left(5.10 \cdot 10^5 \cdot x_2 + 1.20 \cdot 10^6 \cdot x_3 + 1.22 \cdot 10^4\right) \cdot x_3 \cdot x_5 \end{aligned} \tag{11}$$

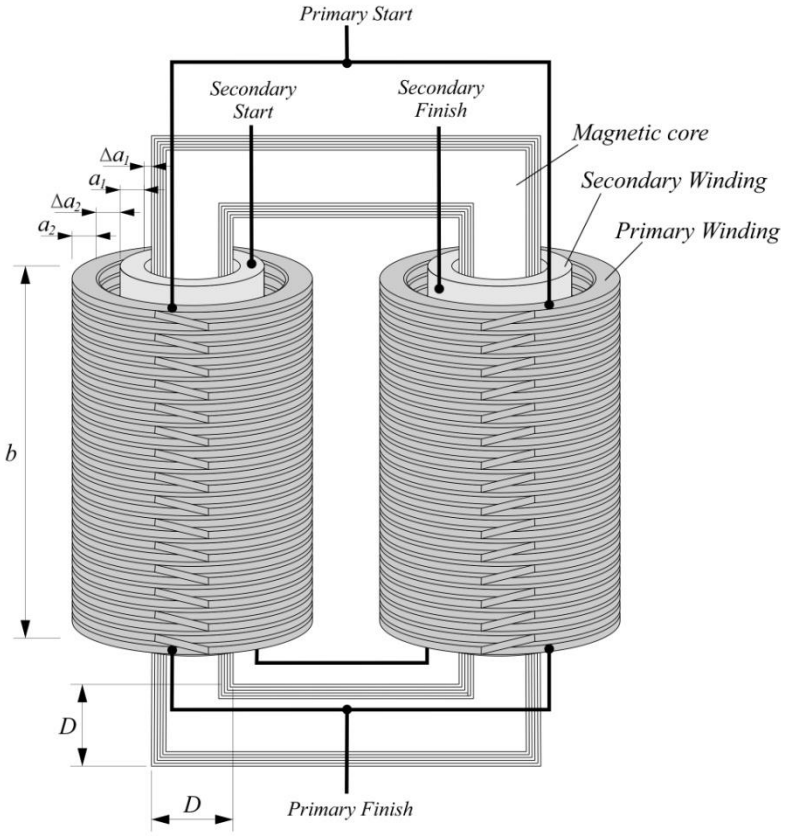

Fig. 2. Active part of a booster transformer – main dimensions

The inequality constraints should be modified to the less or equal format, g(x) ≤ 0. The constraints of the analyzed mathematical model are entered as follows: Constraint 12 match to booster transformer nominal rating, Constraint 13 match to guaranteed load losses, Constraint 14 match to guaranteed no-load losses and Constraint 15 guaranteed impedance of booster transformer secondary side. Constants in front of decision variables have been taken from the **Fig.2** and reference [3].

$$208.6 \cdot x_1 \cdot x_2^2 \cdot x_3 \cdot x_4 \cdot x_5 \cdot 10^3 - 253 \leq 0 \tag{12}$$

$$\left(2.12 \cdot 10^{-7} \cdot x_2 + 4.06 \cdot 10^{-7} \cdot x_3 + 4.53 \cdot 10^{-9}\right) \cdot x_3 \cdot x_4^2 \cdot x_5 - 2150 \leq 0 \tag{13}$$

$$\left(-0.30 \cdot x_1^2 + 0.85 \cdot x_1 - 0.04\right) \cdot \left(\left(2.57 \cdot 10^4 \cdot x_5 + 1.6 \cdot 10^5 \cdot x_3 + 2.04 \cdot 10^3\right) \cdot x_2^2 + 1.33 \cdot x_2^3\right) \cdot 0.25 - 95 \leq 0 \tag{14}$$

$$\left(0.02 \cdot x_2 + 0.01 \cdot x_2 \cdot x_3 + 0.04 \cdot x_3 + 1.13 \cdot x_3^2 + 1.4 \cdot 10^{-4}\right) \cdot 208.6 \cdot 0.012 \cdot x_3 \cdot x_4 / x_1 \cdot x_2^2 - 0.09 \leq 0 \tag{15}$$

These values are multiplied by a penalty co-efficient, which is then added to the objective function to continue the process of optimization. This process is often termed as penalty function approach.

Table 1 The optimal value of decision variables.

Parameter	Value
X_1	0.210110
X_2	0.246452
X_3	0.017270
X_4	2.560860
X_5	0.620250

Table 2 Comparative results of two methodologies

	B	***g***	***D***	***a***	***b***	**Cost of Active part**
DE Algorithm	0.21	2.56	246	17	620	3685
Lagrange with New.Rap.[10]	0.23	2.78	248	18	610	3982

The parameters X_1, X_2, X_3, X_4, X_5 match respectively to the magnetic flux density (*B*), the diameter of core leg (*D*), the width of secondary winding (*a*), the current density of secondary winding (*g*) and the core window height (*b*).

5. Conclusion

This paper presents an efficient implementation of the Differential Evolution algorithm with a penalty function approach, applied to designing 200 Amps Booster Transformer. The booster transformers essentially operate as a 1:1 ratio current transformers and are installed at approximately 2.5-3.5 km intervals along overhead electrified lines. These transformers are used in catenary systems in England, Sweden, Korea, India and others. The booster transformers are also used in many other countries such as Norway and Denmark. Our penalty function approach integrates established techniques in existing EA's in a single unique algorithm. Moreover, this approach is easy to implement and its computational cost is relatively low. The use of the DE computer program is applied to the analyzed mathematical model. In the first methodology, the single objective DE optimization showed that single optimum could be obtained quickly, even when constraints in the penalty function method are complex. Compared with the second methodology in the same table, the cost of materials for the active part of the reviewed object are lower by approximately 8 %.

Fig. 3. As built 200 Amps Booster Transformer

References

[1]. R. Salkoski, “Heuristic algorithm for multicriterial optimization of power objects”, PhD Thesis, University” SS. Cyril and Methodius” FEIT, Skopje, R. Macedonia (2018)

[2]. R. Salkoski, I. Chorbev.: Design optimization of distribution transformers based on Differential Evolution Algorithms, ICT Innovations2012 Web Proceedings ISSN 1857-7288, page 35-44.September 2012, Ohrid

[3]. R. Salkoski.: Selection of an optimal variant of 3-phase transformers with round and rectangular section of the magnetic core from aspect of minimum production costs. Master Thesis, Electrotechnical University in Skopje (2000).

[4]. A.Vasan,“Optimization Using Differential Evolution.” Water Resources Re-search Report. Book 22. Department of Civil and Environmental Engineering, The University of Western Ontario, Publication Date 7-2008.

[5]. A.Zamuda, J.Brest, B.Bošković, V.Žumer,“Differential Evolution with Self-adaptation and Local Search for Constrained Multi-objective Optimization,” IEEE Congress on Evolutionary Computation (CEC), pp. 195-202 (2009)

[6]. DE Homepage, http://www.icsi.berkeley.edu/~storn/code.html

[7]. B.V. Babu, M. Mathew, L. Jehan .: Differential Evolution for MultiObjective Optimization. Chemical Enginering Department B.I.T.S. Pilani, India (2005).

[8]. Onwubolu, G. C., and Babu, B. V.: New Optimization Techniques in Engineering, Springer-Verlag, Germany (2004).

[9]. P.V. Kenneth., S.M. Rainer.: Differential evolution - A simple evolution strategy for fast optimization. Dr. Dobb's Journal, 22, 18-24 and 78. (1997).

[10]. P.V. Kenneth., S.M. Rainer., L.A. Jouni: Differential evolution: A practical approach to global optimization. Springer-Verlag, Berlin, Heidelberg (2005).

[11]. Mezura and Montes: E. Laboratorio NI Avanzada, Rébsamen 80, Centro, Xalapa, Veracruz 91090, Mexico, Velazquez-Reyes, J., Coello Coello, C.A.: Modified Differential Evolution for Constrained Optimization, pp 25 – 32, Conference Publications, Evolutionary Computation, CEC 2006 (2006).

[12]. U.K. Chakraborty (Ed.).: Advances in Differential Evolution, Mathematics & Computer Science Department, University of Missouri, St.Louis, USA, Springer-Verlag Berlin Heidelberg (2008).

[13]. J. Rönkkönen, S., Kukkonen, K. V. Price.: Real-parameter optimization with differential evolution. Proc. IEEE Congr. Evolut. Comput. Sep. 2005, pp. 506–513, Edinburgh, Scotland (2005).

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PERFORMANCE COMPARISON OF C++ AND JAVASCRIPT (NODE.JS – V8 ENGINE)

Kristijan Stefanoski, Aleksandar Karadimche, Ile Dimitrievski

Abstract: The computational performance of programming languages has been a developer's challenge for a long time. In this research paper, we propose a performance comparison of C++ and JavaScript. On one side we have the well-known and proven procedural programming language C++ that is still used today. On the other side is the interactive JavaScript, typical for browser engines that offer just-in-time compilation for improved performance. The main objective of the comparison was to use common searching and sorting algorithms for data arrays. Both programming languages have their own advantages and disadvantages since C++ and JavaScript are mostly used for different kinds of programming, and rarely overlapping.
Keywords: computational performance, JavaScript, C++, searching and sorting algorithms

1. Introduction

The C++ presents one of the most widespread programming languages since its creation back in the 20th century and even today. It serves not just for a single purpose but various purposes in the programming world.

On the other hand, the Web Technologies and web programming languages that mainly run in the browser, like JavaScript are often treated as slower in regards to languages that interact much easier with the machine. In order JavaScript to run in the browser various engines are used that firstly were interpreters, but today nearly all of the engines offer just-in-time compilation for improved performance. JavaScript engines are developed by web browser vendors and nearly every major browser has one. Chrome V8 is an open-source JavaScript engine developed by The Chromium Project for Google Chrome and Chromium browsers. It is treated as a high-performance JavaScript engine and is written in C++.

Another breaking point for the JavaScript world was the creation of the Node.js run-time environment that allowed programmers to run JavaScript code on the server, outside of the browser. Node.js also uses V8 engine that parses and runs the written JavaScript code, thus all code comparisons bellow will be between JavaScript (Node.js) and C++.

Since C++ is categorized as one of the most powerful programming languages of our time, the major focus of this research is to provide in-depth comparison while executing various similar tasks on similar data-types in both C++ and JavaScript. All data presented in this research, the time needed for various tasks, the time difference is presented in seconds/milliseconds.

"High level abstraction has acted as a catalyst for Javascript's wide adoption but at the cost of a severe performance penalty. Re-cent studies show that Javascript implementations can be up to 50x slower than corresponding C/C++ implementations [2]. This per-formance gap is mainly due to bytecode interpretation of dynam-ically typed Javascript code as opposed to native code generation for statically typed languages C/C++. As Javascript applications become more complex in the future, this performance gap is expected to further increase [2]."

So the above paragraph is also a reference to the performance gap that we can expect when using JavaScript, against a language like C++, which is correct as the complexity of the program increases although on a task that is not that processing power demanding the performance of JavaScript would be sufficient to handle most of the tasks in time.

Because Node is mostly used for web applications, the following paragraph is comparison of Node to Java, and similarly it leads to a conclusion that Node is suitable for IO Heavy web applications.

"Web Applications do a lot of IO. First, a request is received from the browser; that's IO. Second, the application typically fetches the requested data from a database; that's IO. Once it has all the response data computed, it then sends it back to the browser; that's IO. All the while, the application is probably maintaining an application log, and that's IO too. Web applications, in fact, spend most of their time doing IO, not computation.

If servicing each request were a race between the two technologies, every time more IO is performed, Node would win a little bit more. What this amounts to is that Node is incredibly well suited for web applications."[1]

As we know Node.js has a non blocking IO, which is the reason why it will can out-perform some of the blocking IO languages, unless the logic is handled differently in that language or Node.js code is written in such a way to loose the power of non-blocking IO and make it a blocking one.

This research is structured in this sections, inserting data in dynamic arrays, applying common searching algorithms on small and large data, applying common sorting algorithms on small and large data, Radix Sort and conclusion and discussion

2. Inserting data in dynamic arrays

As other scripting languages JavaScript also has dynamic arrays, their size is not predefined, and the type of data too.

Also in JavaScript, the Array type is defined as an object meaning it is not a true contiguous-memory array, which ultimately might lead to some lack in performance while inserting or deleting data.

On the other hand in C++ Vector would be the JavaScript equivalent, since they are same as dynamic arrays with the ability to resize itself automatically.

Bellow follows the comparison while inserting different amount of data in Array and Vector and the time needed for the operations to complete in both situations.

1. Inserting 1.000.000 integer elements in Array and Vector

In Node.js inserting 1.000.000 integers with the following code:

```
let array = [];
for(let i = 0; i<1000000; i++){
   array.push(i);
}
```

And logging the time before the begging of the insertion and after it leading to the following result:

14:21:5:254 - Before
14:21:5:276 – After
Ultimately leading to a difference of 2***2ms***.

In C++ performing the same operation on Vector with the following code:

```
vector<int> v1;
   for(int i=0;i<1000000;i++){
      v1.push_back(i);
   }
```

Logging the time before and after:
14:28:47:448 - Before
14:28:47:463 - After

Which leaves us with a difference of ***15ms***, or ***7ms*** faster computation time than JavaScript.

Boosting the amount of integers to 3 million resulted in a ***54ms*** difference in Node compared to the ***49ms*** in C++.

Bellow follows a Figure 1, which shows the comparison of required time to run the certain operations and the number of entries to be inserted with C++ and JavaScript.

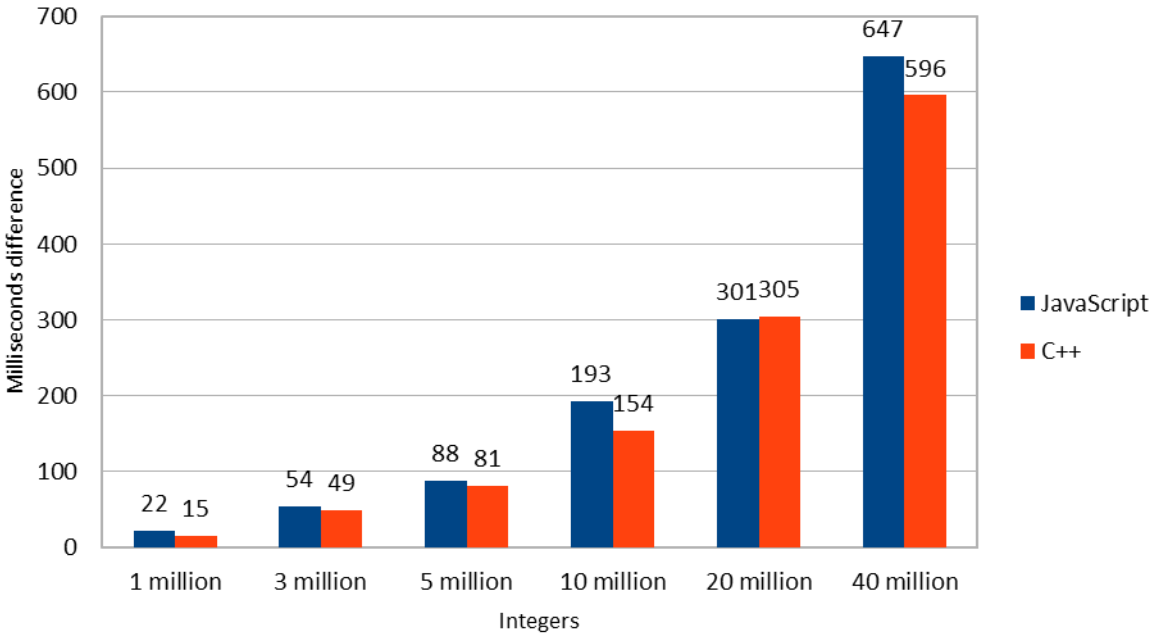

Fig. 1. Comparison required time C++ and JavaScript

After running several more test while an increasing number of elements to be inserted the conclusion is presented in the above graph. C++ resulted in a slightly faster insertion time, in terms of milliseconds.

Although not always as can be seen while inserting 20 million entries JavaScript has shown to be faster even after running the same code several times the results were always the same.

3. Applying common searching algorithms on small and large data

In computer science, a search algorithm is an algorithm which solves the search problem, namely, to retrieve information stored within some data structure, or calculated in the search space of a problem domain, either with discrete or continuous values.

3.1. Linear Search

Searching for the value located on index position n/2 in an array of 1 million entries.

C++ code used for linear search

```
int search(int arr[], int n, int x)
    {
        int i;
        for (i = 0; i < n; i++)
            if (arr[i] == x)
        return i;
        return -1;
    }
```

And logging the time before the begining of the search and after it leading to the following result:

21:31:46:196 - Before

21:31:46:197 – After

Leaving a 1ms difference in this case.

The function used with Node.js :

```
function linearSearch(array, toFind){
   for(let i = 0; i < array.length; i++){
     if(array[i] === toFind) return i;
    }
    return -1;
  }
```

Results from the execution:

Before : 21:34:36:605

After : 21:34:36:608

Which means a 3ms difference or 2ms more running time than the same C++ code.

Bellow the Figure 2, presens the results when increasing the number of elements higher than 1 million integer entries and always looking for the mid-placed value.

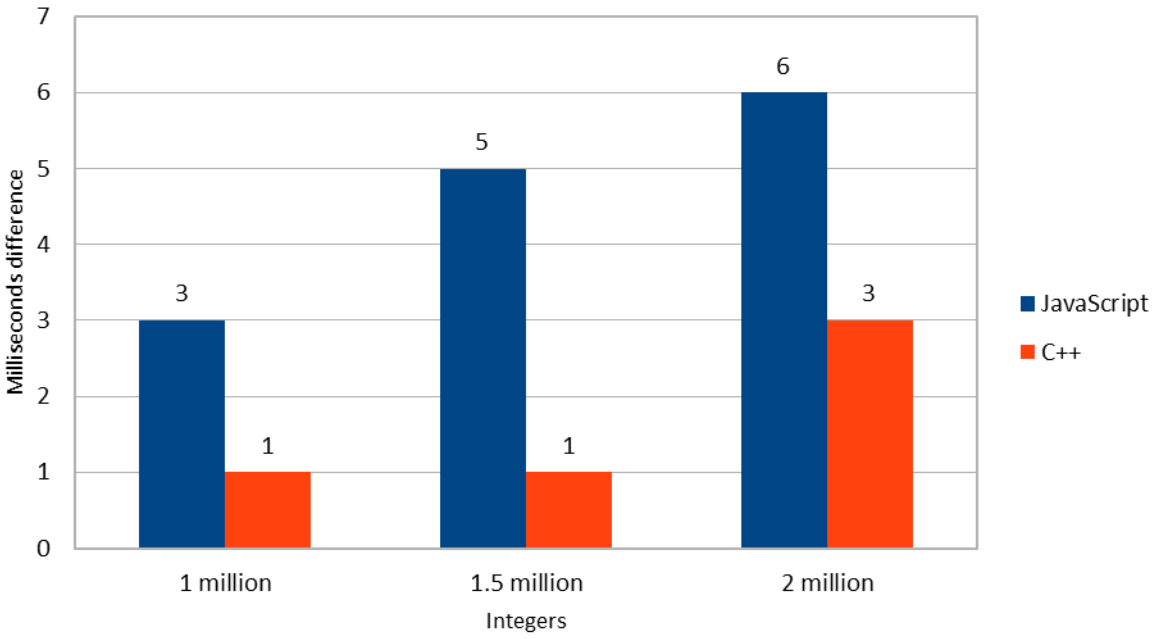

Fig. 2. Performance comparison of searching algortims C++ and javaScript

4. Applying common sorting algorithms on small and large data

A Sorting Algorithm is used to rearrange a given array or list elements according to a comparison operator on the elements. The comparison operator is used to decide the new order of the element in the respective data structure.

4.1. Selection sort

In computer science, selection sort is a sorting algorithm, specifically an in-place comparison sort. It has O(n^2) time complexity, making it inefficient on large lists, and generally performs worse than the similar insertion sort.

All numbers inserted into the arrays for sorting are generated using a randomizing function for both C++ and Node.js.

A) Testing selection sort on 10.000 entries in C++ with the following code:

```
void selectionSort(int arr[], int n)
{
   int i, j, min_idx;
    for (i = 0; i < n-1; i++)
   {

      min_idx = i;
      for (j = i+1; j < n; j++)
      if (arr[j] < arr[min_idx])
         min_idx = j;
      swap(&arr[min_idx], &arr[i]);
   }
}
```

Time results from running the above example:
Before : 21:53:09:861
After : 21:53:09:984
Which leaves us with a 123ms time difference even on 10.000 entries.

B) Testing the same example in Node.js with the code bellow

```
function selection_sort(A) {
   var len = A.length;
   for (var i = 0; i < len - 1; i = i + 1) {
      var j_min = i;
      for (var j = i + 1; j < len; j = j + 1) {
         if (A[j] < A[j_min]) {
            j_min = j;
         } else {}
      }
      if (j_min !== i) {
         swap(A, i, j_min);
      } else {}
   }
}
```

The result from testing the Node.js code:
Before: 21:56:40:79
After: 21:56:40:144
Or ***65ms*** difference which is nearly half the time required in C++, leaving to a conclusion that dynamic JavaScript arrays perform faster when it comes to sorting, compared to standard C++ arrays.

The performance comparison of sorting algortims C++ and JavaScript with different input sizes can be found bellow.

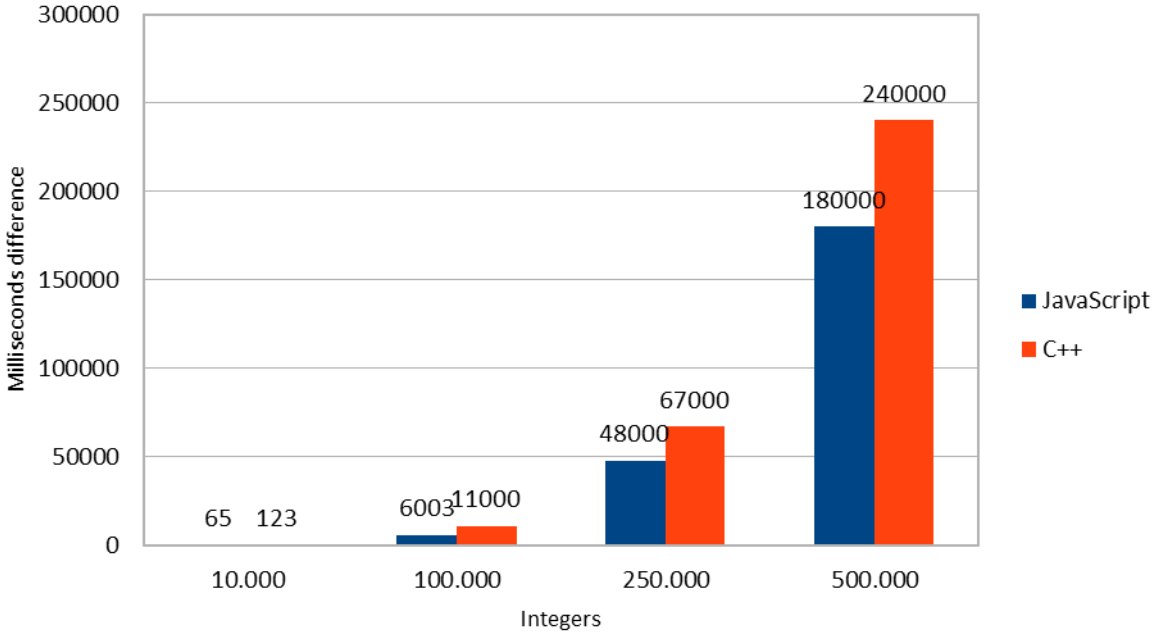

Fig. 3. Performance comparison of sorting algortims C++ and JavaScript

The performance comparison of sorting algortims C++ and JavaScript ois given in Fugure 3. Both C++ and Node.js have increasing the number of entries increases the processing time, and that increase is highly noticed as well, it can go well over **1 minute** to process over **1.000.000 random** array entries.

4.2. Radix Sort

In computer science, radix sort is a non-comparative integer sorting algorithm that sorts data with integer keys by grouping keys by the individual digits which share the same significant position and value.

Since sorting algorithms running time increases with entries in the array, the starting point for Radix sort will be placed around 1000 entries at the beginning.

Running a test on 1000 entries in C++ with the following code:

```
void countSort(int arr[], int n, int exp)
{
	int output[n], i, count[10] = {0};
	for (i = 0; i < n; i++)
		count[(arr[i] / exp) % 10]++;

	for (i = 1; i < 10; i++)
		count[i] += count[i-1];

	for (i = n - 1; i >= 0; i--)
	{
		output[count[(arr[i] / exp) % 10] - 1] = arr[i];
```

```
                count[(arr[i] / exp) % 10]--;
        }
        for (i = 0; i < n; i++)
                arr[i] = output[i];
}

void radixsort(int arr[], int n)
{
        int exp, m;
        m = getMax(arr, n);

        // Calling countSort() for digit at (exp)th place in every input.
        for (exp = 1; m/exp > 0; exp *= 10)
                countSort(arr, n, exp);
}
```

Because of the small number of entries running the above code required just ***1ms*** in order to return the results.

While in Node.js the following code has been used to run a test on 1000 entries again which are randomly generated in both cases.

```
function getMax(arr) {

   let max = 0;
   for (let num of arr) {
      if (max < num.toString().length) {
         max = num.toString().length
      }
   }
   return max
}
function getPosition(num, place) {
   return Math.floor(Math.abs(num) / Math.pow(10, place)) % 10
}
function radixSort(arr) {

   const max = getMax(arr); // length of the max digit in the array

   for (let i = 0; i < max; i++) {
      let buckets = Array.from({ length: 10 }, () => [])
      for (let j = 0; j < arr.length; j++) {
         buckets[getPosition(arr[j], i)].push(arr[j]); // pushing into buckets
      }
```

And the first run with 1000 entries gives worse performance compared to C++, or exactly **11ms** runtime.

The above test cases are expanded to more entries as in previous topics, detailed comparison can be seen in the Figure 4 bellow:

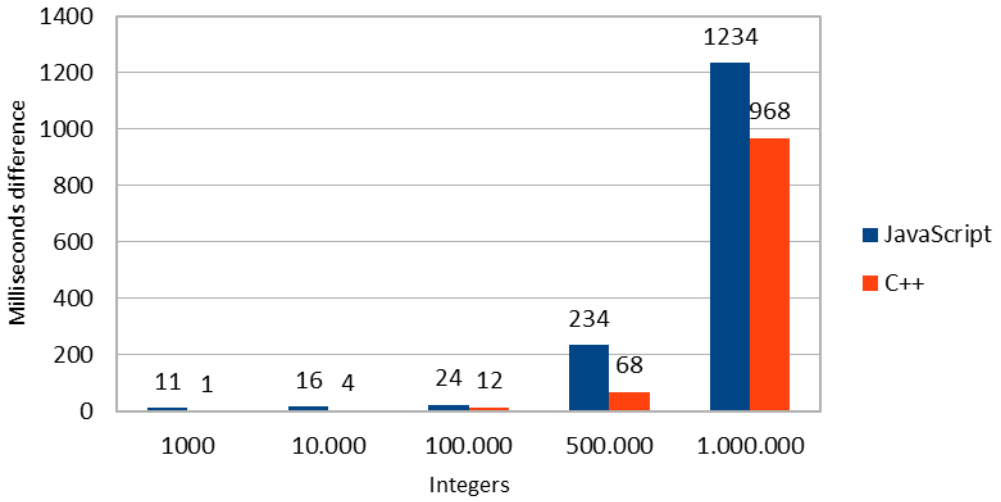

Fig.4. Detailed comparison of Radix sorting algortim with C++ and JavaScript

5. Conclusion and discussion

In the beginning, the part where we were looking only to insert data in arrays, the difference was not that noticeable, but as more processing power demanding algorithms are run C++ gives the expected better result. Also we should take in account that on first place in each of the tests what is happening is that we need to create the arrays and insert data at the first place before running any algorithm over that data, so there is slight difference at the first place in the data structure (arrays) in C++ and Node.js, how the memory is allocated and how fast the insertion if happening (first topic of this research).

The time is logged by displaying a log when the program first is executed and before it exists, the time difference is the result of the subtraction between the two logs of the time. In most cases, the time difference is in milliseconds.

The main reasons why C++ gives better performance are outlined below:

- C++ is a compiled language, meaning there is no run-time parsing of source code and no just in time compilation too.
- C++ uses fixed types if a variable is defined to be an integer data type and assigned a certain value, to achieve that, all that happens is one instruction where to store that variable in memory.
- In JavaScript, on the other hand, a variable is not declared with a fixed data type, it could be afloat or an integer or a string, and additionally we are not limited to change the data type and store any other kind later as the program continues with the workflow. Every assignment has to go through overheads of type checking and conversion."

"Scripting languages such as JavaScript [3] and Python [4]rely on dynamic typing. A single operation can handle multiple data types since the variables do not have types when the programmers write the code and might point to objects of any type. When the code is executed, the type of the target data is dynamically resolved and an appropriate operation is selected for the type. For example, if a program accesses a property x of the data, then how to retrieve x from the data depends on the type of the data and can only be determined at runtime. In contrast, with static typing (as in C), the type is fixed for each variable when the code is written. The specialized code is written for different types of data. Dynamic typing simplifies the programming while adding runtime overhead for resolving the types, which is not required with static typing. Suppose that the

code accesses a property x of some data in a scripting language. The language system resolves the type of the data, resolves an access method that can locates x for the resolved type, and executes it. The runtime overhead of resolving the types is the cost of the resolution processes." [3]

- C++ does not make use of "garbage collection", on the other hand, JavaScript at times stops and must take a look at every reference to allocated memory and check if it is no longer needed. In C++ the programmer has to do so.

Of course, both languages have advantages and disadvantages, since C++ and JavaScript are mostly used for different kinds of programming, and rarely overlap. But having JavaScript run in the browser and on the server gives a lot of space for developers that now can develop a full-stack application using the same language front and back end.

References:

[1]. Jenson, J. "Performance Comparison: Java vs Node", available online https://www.tandemseven.com/blog/performance-java-vs-node/ [accessed 26.08.2019]

[2]. Mehrara, M., Hsu, P.C., Samadi, M., Mahlke, S.: Dynamic Parallelization of JavaScript Applications Using an Ultra-lightweight Speculation Mechanism. In: Proceedings of the 17th IEEE International Symposium on High Performance Computer Architecture, HPCA 2011, pp. 87–98 (2011).

[3]. Ogasawara, T. "Workload characterization of server-side JavaScript," 2014 IEEE International Symposium on Workload Characterization (IISWC), Raleigh, NC, 2014, pp. 13-21. doi: 10.1109/IISWC.2014.6983035.

[4]. Tiwari D. and Solihin, Y. "Architectural characterization and similarity analysis of sunspider and Google's V8 Javascript benchmarks," 2012 IEEE International Symposium on Performance Analysis of Systems & Software, New Brunswick, NJ, 2012, pp. 221-232. doi: 10.1109/ISPASS.2012.6189228.

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INCREASING THE EFFICIENCY THROUGH THE DIGITALIZATION OF GOVERNMENT SERVICES

Jovanka Damoska Sekuloska

Abstract: Application of Information and communication technologies (ICT) is a permanent process happening in any area of society. E-government as a new approach in the process of delivering the public services should simplify communication and increase availability to the users on the one hand, and on the other reduces the time and costs for provision and consumption of the services. The digitalization of public services is essential process aimed to follow the trends of information society growth, but also to offer better and more efficient services to citizens and companies. Digitalization of the public services as an investment is associated with high costs for implementation and maintenance of the digital systems, so the paper's purpose is to analyze the cost and benefits to the citizens and government. Using cost-benefit analysis the paper examines the cost-efficiency and justification of introducing e-services.
Keywords: e-government, public services, digitalization, cost-benefit analysis

1. Introduction

Digitalization of the public services is a continuous process resulted from the development of Information and Communication Technologies (ICTs) on the one hand and the existence of citizen-oriented government policies aimed at enabling and distributing transparent, inexpensive, accessible and inclusive e-services. In such circumstances, digital technologies play a vital role in delivering services, previously unavailable or inaccessible to a huge portion of citizens. According to the UN, the digital government has steered to significant and enduring changes in the way people live and interact with each other, their environment and public services. The UN Survey 2018 highlights a persistent positive global trend towards higher levels of e-government development. The Survey found out countries score "Very- High" with EGDI1 values in the range of 0.75 to 1.00, as compared to only 10 countries in 2003 and 29 countries in 2016. [11]

E-government operating as a platform for sustainable development can generate public value and a range of people-centered benefits. According to Turban et al. [10] e-government refers to the use of information technology in general, and e-commerce, in particular, to improve the delivery of government services and activities in the public sector, such as: providing citizens with more convenient access to information and services, and providing effective delivery of government services to citizens and businesses as well as improving the performance of government employees. It is also an efficient and effective way for governments to interact with citizens, businesses, and other entities and to improve governmental business transactions (such as buying and selling goods), and to operate effectively within the governments themselves.

Digital technologies transform citizens' lives, communities, civil society groups and businesses from passive consumers of data and knowledge to active producers. The increasing use of digital technologies by institutions has dramatically impacted public services and their delivery, through Internet websites and portals, mobile and smartphones, social media, and kiosks located in places accessible to the public [11].

Digital delivery of public services is having a significant impact, as it is much more affordable for an increasing number of users and more cost-effective for governments than traditional supply

[1]EGDI refers to E-Government Development Index is a weighted average of normalized scores on the three most important dimensions of e-government: the scope and quality of online services, the status of the development of telecommunication infrastructure and the inherent human capital scored through the Human Capital Index (HCI)

channels. Digital technologies enable more targeted, personalized and up-to-date service design and delivery. It provides the service user greater benefits than the sole reliance on traditional service channels, in terms of access, convenience through 24/7 availability, savings in time and the cost of travel to physical premises such as offices [11].

Digitalization of the public services is emerging as a catalyst for a sustainable, adaptable and transparent society. It enhances the effectiveness of the public policies, enhances transparency by providing access to information, increases the responsibility and provides the ability to check what the government and public institutions are doing and how well they are doing their job.

The digitalization process is not simple, it implies on implementation of the principles as effectiveness, inclusiveness, openness, trust, and responsibility. It should not be ignored that the process of digitalization consists of cost and benefits at the same time. Due to this, it is very important for any digitalization project to be supported by financial evaluation. Therefore, the following section of the paper will be presented some theoretical aspects referring to the models and tools for evaluation. The central point in the paper presents the application of the cost-benefit model in assessing justification and efficiency of the digitalization through the case of the public service - *Calculation and payment of the fee for a temporary stay of tourists by the local self-government.* The final section contains the conclusions of the analysis and suggestions for further research.

2. Literature review

The use of ICT and e-Government as a new approach aims to increase the efficiency and effectiveness of public sector service delivery, or modernizing or even transforming public administration and society [8]. The process of launching and implementation of e-government is followed by the necessity of evaluation and measurement models as tools in examining the efficiency and economic justification of the digitalization of the public services. Different methods have been proposed in the evaluation of the e-government projects. Referring to the measurement used in the process of evaluation [7] have made classification on hard measurement and soft measurement.

Hard measurements are quantifiable and many authors used them constructing financial models in the process of e-government evaluation. Soft measurements could be used only as an additional measurement in the evaluation of an e-government project because they cannot be quantified. The soft measurements are usually ex-post because they are conducted after the implementation process. For example, the citizen-centric approach relies heavily on citizen feedback when evaluating the impacts of e-government projects [12]. Other models of evaluation [1] include multiple indicators approach like: compatibility, relative advantage, complexity, perceived ease of use, perceived usefulness and trust of the Internet and government.

Financial measures and models are identified as relevant for the evaluation of the e-government projects. As most useful techniques within the financial models are cost-benefit ratio, net present value, return on investment and payback period. Kertesz [5] has used a cost-benefit model in which he identified three basic elements. He suggested that when adopting a new electronic government project, one had to consider pre-implementation cost, implementation cost, and operational cost, while balancing them against benefits for governmental agencies, citizens and customers. Sakowicz [9] paid more attention to the "return on investment" tool. Cost-benefit analysis is identified as fundamental and crucial in any e-government project [6][2].

Although the financial models are very useful tools in the process of quantification the tangible benefits of the e-government projects, at the same time these approaches are criticized and argued exactly for their focus only to direct tangible costs and benefits. Liu and Yuan [4] have identified three limitations of financial measures. First limitation sources by the basement of the process of evaluation on the expected costs and benefits. It means that data on benefits, costs, and discount rates are assumed. Also, the multitude and diversity of benefits and costs for any e-

government project are very hard to be assumed and contribute to the entire complexity of the process [3]. As a limitation of the financial models is also suggested the issue that not all e-government projects are aiming at profit maximization [4].

One of the main drawbacks to these financial models is the absence of the so-called multiplier effect of digital public services to other social, political and economic parties. It means that the side additional effects in the short or long run period caused by the process of digitalization could not be measured in the moment of evaluation, because it is very hard to assume and to anticipate them. According to the World Bank [13], the evaluation of e-government projects estimates the direct benefits only, although it could arise many indirect benefits, called multiplier impacts.

Against the limitations of the financial models, they are considered as an efficient preliminary tool in making a decision to launch or not to launch an ICT project. Basically, the cost-benefit analysis is heavily used by governments to evaluate the desirability of some projects. It is an analysis of the cost-effectiveness of different alternatives in order to see whether the benefits outweigh the costs. Thus, it is a useful tool to assess the efficiency of the investment against the status quo condition.

3. Financial model and analysis

The online distribution of public services is aimed at increasing citizens' satisfaction measured by transparency, accessibility, and efficiency in their use, by achieving greater effectiveness measured by reducing the distribution costs to the citizens. Therefore, the implementation of the process of digitalization of public services should provide a balance between the benefits arising from the online distribution of public services and the costs incurred in their implementation.

Digitalization projects are associated with high costs for the implementation and maintenance of digital systems. The introduction of digital public services also highlights the necessity for effective change management of public service providers. The focus of the e-services is to meet the needs of the users resulting in a number of benefits. Cost-Benefit Analysis (CBA) is an approach and tool for an initial assessment of the cost-effectiveness of the public service digitalization process. The CBA considers the costs and benefits of the public services digitalization projects. Since the main purpose of the paper is to analyze the efficiency and the economic justification of the digitalization process, the research examines the profitability through the case of digitalization of the local self-government service - *Calculation and payment of the fee for a temporary stay of tourists in the Municipality of Ohrid*. It is a public fee charging the landlords to pay to the local government for every night accommodation of the domestic and foreign tourists.

The analysis passes through several phases. Firstly, the analysis identifies the benefits and costs. The proposed model involves two groups of benefits referring to the landlords (private individuals) and local self-government, and accordingly two groups of costs bearing from the digitalization of the service. They are presented in the matrix of the cost and benefits in table 1. In general, the financial costs of an activity are relatively easy to determine. More difficult is the estimation of benefits and intangible costs. This is because some benefits and costs of many activities, especially before the investment takes place, may not be clear.

According to the available official data, within the analysis are suggested and determined the benefits and costs to the private landlord resulting from the digitalization of the public service - Calculation and payment of the fee for a temporary stay of tourists. They are recognized as:

- *Time-saving* - for performing the administrative procedures to settle the obligation about the fee the landlord needs around 1 hour per month. According to the State Statistical Office, the average gross monthly wage is 600 EUR, meaning the hourly rate of 3.7 EUR or 44.4 EUR per year.
- *Costs for transport to the local administration* is assumed to be 2 EUR per month or 24 EUR per year.
- *Costs for paper form* are 0.90 EUR monthly.

- *Costs for a digital certificate* - the price of the cheapest digital certificate in the market is around 14 EUR per year.

Table1. Matrix of the costs and benefits of the digitalization of the public service – Calculation and payment of the fee for a temporary stay of tourists

Benefits to the landlords	**Benefits to the local government**
BL1: Time-saving BL2: Transport cost saving BL3: Paper cost saving	BLG1: Labor-saving BLG2: Office supplies saving
Cost to the landlords	**Costs to the local government**
CLL: Costs for procurement of digital certificate	CLG1: Procurement of the digital system (hardware and software) CLG2: Maintenance and system upgrading CLG3: Training of the employees CLG4: System Depreciation

The analysis takes into consideration the benefits and costs of the digitalization process to the local self-government. They involve:

- *Cost savings* resulting from the employees' rationalization. The annual salary savings would be 21.527 EUR for the reduction of three employees.
- *Office supplies saving* is 500 EUR per year.
- *Procurement and installation of a digital system (hardware and software)*. It is an initial cost. According to the data from the Public Procurement Bureau, the price for such a system is 50.000 EUR.
- *Costs for maintaining and upgrading the software*. According to the data from the Public Procurement Bureau, it costs around 5700 EUR per year.
- *Depreciation costs* - calculated according to the accounting standards for 5 years.
- *Staff training and consultation costs* - would be 1500 EUR per year.,

According to the official data of the Ohrid Municipality, the number of the registered landlords noticed continual growth, reaching 3000 in 2019.

To determine whether the introduction of public service digitalization is a viable option or not, the difference between benefits and costs within the cost-benefit analysis is discounted at a rate of 7.25%. This rate is calculated as the sum between the rate of 2.25% of the government securities since the last auction of the National Bank of the Republic of Macedonia (04.2019) and the premium risk of 5% for the Macedonian economy in 2019 calculated and issued by the Stern Business School. Using the net present value (NPV) technique the analysis determines the net worth of the investment. It means discounting the future annuities (benefits) of the investment by the rate of 7.25%.

The available data for the costs and benefits enables preliminary determination of the economic justification and efficiency of the employment of the digitalization of the public service. Table 2 presents the results of the cost-benefit analysis and net present value for a period of 5 years.

The cost-benefit analysis considers and summarises the benefits and the costs of the ICT investment to both groups of stakeholders (citizens and local self-government).

Table 2. Cost-benefit analysis and NPV (EUR)

	Y0	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**NPV**
Costs	-50,000	59,200	59,200	59,200	59,200	59,200	
Benefits	0	259,495	259,495	259,495	259,495	259,495	
NPV	-50,000	200,295	200,295	200,295	200,295	200,295	765,781
Total savings	-50,000	150,295	350,590	550,885	751,180	951,475	

From table 2, it could be seen that the total benefits outweigh the total costs immediately after the first year of the implementation. The discounting of the cash flows (differences between costs and benefits) at the rate of 7.25% indicates on a positive present value of 765.781 EUR, suggesting that the investment in the digitalization of the public service – Calculation and payment of the fee for a temporary stay of tourists is a worthwhile project.

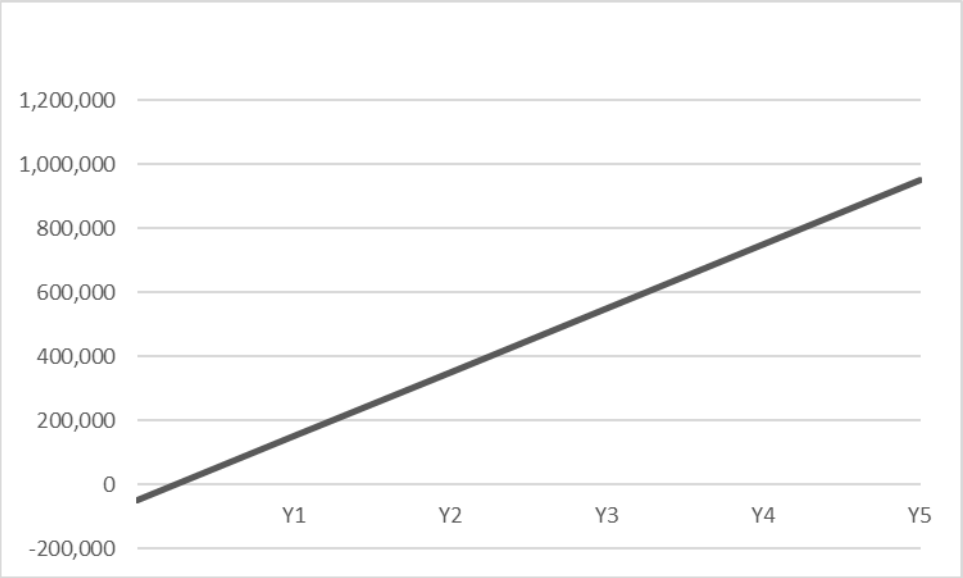

Fig. 1. Chart of the total savings

The chart of the total savings presented in Figure 1, shows that the investment, according to the projected and assumed costs and benefits level, is worthwhile already in the first year of implementation. The analysis is based only on the costs and benefits easily quantified. It doesn't involve the benefits that could appear in the qualitative or intangible form. Based on the tangible benefits and costs the analysis suggests a valuable benefits and advantages after the digitalization of the public service to both parties, citizens and local self-government.

Concerning the citizens as users, the benefits could be higher for 5.34 times, against the period before digitalization. On the other hand, the costs for the citizens could reach only 19% of the costs before the implementation of the digital service. Referring to the local self-government, the benefits will be higher for 1.25 times in the period for 5 years. At the same time, due to the digitalization, the costs are going to be reduced for 22.5% against the period before the digitalization.

4. Conclusion

Digitalization of the public services as a process is being extensively implemented by all the governments globally. Since the process of implementation of e-government projects is very complex, influencing many users and stakeholders, it is needed to understand, determine and quantify the impact of e-services in order for the process to be more available, accessible, transparent and economic justified. Due to, the evaluation of efficiency and effectiveness is necessary before the launching of the public services digitalization process. Through the case of digitalization of the public service – *Calculation and payment of the fee for a temporary stay of tourists*, the paper analysis the efficiency and the economic justification of the potential digitalization project. Using cost-benefit analysis (CBA) it determines and assesses the costs and benefits relevant and quantifiable to the project. Cost-benefit analysis is a compelling input to the

decision making the process. By determining the economic impact of the digitalization project, the local self- government has valuable insight into the contribution and influence to all stakeholders and users of the services.

On the base of the CBA upgraded by the NPV analysis, it could be concluded that it is likely that the benefits of launching and implementation of public e-services are greater than the costs. The potential benefits are determined for both sides, to the citizens and to the local self-governments Generally, as the most relevant benefits to the local self-government are: savings, efficiency gains and employment of innovative tools for establishing and maintaining cooperation with the citizens. As the most important benefits to the citizens could be recognized the time and money-saving, as well a better service delivery.

The purpose of this paper was to provide a foundation for empowering the local self-governments to launch digital projects and to start a higher transition to e-service delivery in most areas of the local government. The analysis does not involve the intangible or the so-called soft benefits which reflect the emotional and qualitative nature of the user's benefits. So the development and employment of a comprehensive model that will analyze both aspects, tangible and intangible benefits of the digitalization process of the public services, will be the next challenge for further research.

References

[1]. Carter L. and Belanger F. The utilization of e-government services: citizen trust, innovation and acceptance factors, Information Systems Journal 15, Blackwell Publishing Ltd. 2005, 5-25,

[2]. Glazer A., Kanniainen V. and Niskanen E. Bequests, control rights and cost-benefit analysis, European Journal of Political Economy, 19, 2002, pp. 71-82.

[3]. Irani, Z., Love, P. E. D., Elliman, T., Jones, S., & Themistocleous, M. Evaluating e-government: learning from the experiences of two UK local authorities. Information Systems Journal, 2005,15, 61–82.

[4]. Kachwamba M. and Makombe I. Evaluating the Cost-Benefits of E-Government Projects: Rationale for Going Beyond Objective Financial Measures, International Journal of eBusiness and eGovernment Studies, 2011, Vol 3, No 1.

[5]. Kertesz, Sorin. Cost-benefit analysis of e-Government investments, J.F. K School of Government, Harvard University, 2003

[6]. Khan, M. Y. and Jain, P. K. Capital budgeting: Principles and techniques in Financial Management (pp.171 -273) McGraw-Hill Publishing, 2001

[7]. Liu Shuhua Monica and Yuan Qianli. Urban Community Grids Management in Metropolitan China: A Case Study on Factors Contributing to Mobile Governance Success; E-Government Success around the World: Cases, Empirical Studies and Practical Recommendations, 2013.

[8]. Nielsen Morten Meyerhoff. eGovernance Frameworks for Successful Citizen Use of Online Services: A Danish-Japanese Comparative Analysis, Journal of Democracy JeDEM, 2017, 9(2):68-109.

[9]. Sakowicz, M. How to evaluate e-government? different methodologies and methods Warsaw School of Economics, Department of Public Administration, 2005

[10]. Turban E., King D., Lee J.K., Liang T.P., and Turban D.C. Electronic Commerce: A Managerial and Social Networks Perspective 8th ed. Springer, 2015

[11]. United Nations, E-Government Survey, Department of Economic and Social Affairs, New York, 2018.

[12]. Wang L., Bretschneider S., and Gant J. Evaluating Web-based e-government services with a citizen-centric approach, in Proceedings of the 38th Hawaii International Conference on System Science, 2005. IEEE.

[13]. World-Bank. Shaping the Future of Water for Agriculture: A Sourcebook for Investment in Agricultural Water Management. Washington: World Bank, 2005

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THE END OF THE BLOCKCHAIN AS WE KNOW IT

Jovan Karamachoski

Abstract: The craze for Blockchain technologies is reaching the pick. After the turbulent 2018, these technologies showed their main problem, and that is scalability. The two most accepted platforms, Bitcoin and Ethereum, struggled to serve the enormous increase in the number of transactions. This created disbelief that Blockchain is future-proof technology. Majority of the existing Blockchain platforms are using the traditional single-chain structure with one of the two well-known consensus algorithms, Proof-of-work or Proof-of-stake. It is obvious that the problem in these distributed and decentralized databases are the need for complete synchronization of the database (the ledger) in real-time, or near real-time, in every node. To overcome this scalability issue, the Blockchain community offers several solutions. Main ideas are the implementation of Proof-of-stake or other derivatives of this consensus algorithm, implementation of sharding and off-chain transaction offloading. These ideas will increase transaction throughput significantly, especially in the financial Blockchain platforms. Besides the financial implementation scenario, Blockchain technology promises even better improvements in the non-financial scenarios. The researchers are developing advanced mechanisms to adapt the Blockchain technology in non-financial implementation scenarios like IoT, Healthcare, Industry 4.0, supply chains and many others. The current Blockchain technologies are extremely expensive to be implemented in scenarios where the users have to store huge amount of textual data in the Blockchain ledger, so new generations of Blockchain technologies have to be developed.
Keywords: Blockchain, scalability, consensus algorithm, database, non-financial scenarios

1. Introduction

Blockchain technology promises a worldwide self-sustainable solution for an everlasting database with a lot of advantages. The extreme success of the Blockchain technology, particularly the Bitcoin [1] and Ethereum [2], set unexpected problems to these systems as a whole. The development of Ethereum Virtual Machine (EVM) makes the network capable to implement self-executable scripts and automate the processes in the network. These self-executable scripts are known as Smart contracts.

The main implementation area is in finance by the introduction of digital money. Besides that, the researchers have spotted the potential for implementation of these technologies in other scenarios by use of the capabilities build in EVM. Opposite to the public nature of the Bitcoin and Ethereum Blockchain technology, there is a private type of Blockchains where the management of the network and correctness of the data records are checked by particular nodes with a given role. Most important private Blockchain technology is IBM Hyperledger [3].

The paper is structured as follows: Section 2 describes the first version of the Blockchain technology and its main benefits and weaknesses, Section 3 gives the main concept for next generation of Blockchain technologies, Section 4 introduces the non-financial usage of Blockchain technologies and Section 5 concludes the paper.

2. Blockchain technology 1.0

The deployment of the Bitcoin in 2009 officially solved several problems of previous technologies related to the time stamping and synchronization and non-repudiation of the data in a common ledger. The main idea for digital time-stamping and database synchronization to notarize documents, dates bask in 1991 with the academic solution provided by Stuart Haber and W. Scott

Stornetta [1]. Bitcoin is built on top of this idea by adding the idea for digital money and implementation of proof-of-work as a consensus algorithm.

In general, to protect the system from intentional mistakes and errors the Blockchain system implements a one-way function to the data entries in the system. The structure of the data block gives the strength of the Blockchain system against several potential attacks. The main advancement in the structure is the implementation of the output of the hash function of one data block in the header of the next data block. This way the system is creating a chain of interrelated consecutive block that is almost impossible to be changed. Additional resistance to attacks is introduced by the implementation of a consensus algorithm where the parties in the network agree upon single truth in the network, even though they do not know each other. This is the Byzantine fault tolerance (BFT) [4] property of the system. Two main consensus algorithms are proof-of-work and proof-of-stake with several alternatives to optimize system performance. Figure 1 presents the main structure of the data blocks from the Blockchain database (ledger).

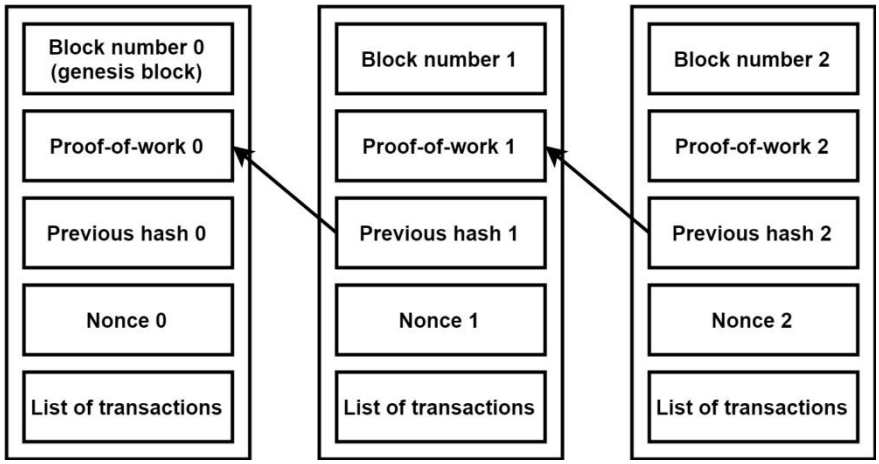

Fig. 1. Blockchain technology main structure

According to the characteristics of the current Blockchain solutions, most of them are from the similar, single chain type, implementing consensus algorithms that are Byzantine fault tolerant. After the craze for the cryptocurrency on the markets and the huge spikes of the number of transactions, these technologies showed their weakness. Practically, the Blockchain systems were almost non-functional due to extensive increase in the number of transactions between the users and extensive waiting time to verify the transaction.

The last decade in the development and deployment of Blockchain technologies shows most of the problems related to the maintenance of fully distributed and decentralized systems. The two of the most famous Blockchains, Bitcoin and Ethereum, are often accused of their power inefficiency. The actual backers of the systems, known as miners, practically are solving compute-intensive puzzle, so they are spending lot of energy to finalize the algorithm. The estimated power consumption of these networks with over 75% of total market cap, is estimated to 100 TWh per year in 2018 when they pick in popularity [5][6]. Besides this drawback of the two main Blockchain platforms, the general conclusion from the problems and the failure of every Blockchain technology, and also main cause for the slow adoption of the Blockchain solutions is the scalability. Likewise Bitcoin and Ethereum platforms, there are plenty of other cryptocurrencies like, Ripple [7], Litecoin [8], EOS [9] who are offering the same general functionality with slight improvements of scalability over the Bitcoin and Ethereum, but with decreased trust and security.

The scalability issue is a multidimensional problem. Mainly there a four scalability issues: scalability of the storage, scalability of the verification throughput, latency inflexibility and address

space scalability. In the next generations of Blockchain technologies, there is a need to address this scalability issues.

3. Blockchain technology 2.0

The development of next generation of Blockchain technologies focuses mainly on delivering a solution for scalability issue regarding the transaction throughput or verification throughput. Ethereum in its second generation announces solving the problem with the scalability of the number of transactions by implementation proof-of-stake consensus algorithm. According to Vitalik Buterin, the co-founder of Ethereum, there is trilemma regarding the decentralization, scalability and security parameters [10]. This means that any improvement in scalability will sacrifice the degree of decentralization and the security of the network.

In the following generations of Ethereum, the focus will be in further improvement of the transaction throughput by the implementation of sharding [11]. The speedup in the transaction rate will continue with the implementation of off-chain transaction capabilities similar to the Lightning network [12]. It is obvious that the main intention is to increase the transaction rate, which means the main focus of the Ethereum developers is the financial implementation scenarios of Ethereum. The long term development plans for Ethereum, bring focus to the scalability improvement by implementation of either crypto-economic algorithms or use of helper chains (like Plasma chains [13] and State channels [14]). With the helper chains, the idea is to declog the main chain from incomplete transaction or transaction closed in one platform or use-case.

4. The future of non-financial Blockchain systems

The development of EVM and introduction of Smart contracts raised the awareness of the academia about the potential non-financial implementations of Blockchain technologies. Researchers are seeing huge potential in the Blockchain technology to offer IoT services on a worldwide scale, to enhance the healthcare system, improve the Industry 4.0 standard, cloud storage, supply chains, digital identity, energy market, Digital Rights Management, Ownership management and many more. Most of these implementation scenarios are almost impossible to be implemented on a large scale on the current Blockchain platforms due to expensive maintenance and the scalability issues that are pointed out. This means that the development of future-proof non-financial Blockchain solution needs a definition of a particular protocol to suit the requirements for the particular scenario.

There are several projects developing a Blockchain for non-financial implementation, like IOTA [15], Sia [16], Datum [17], VeChain [18]. In a non-financial scenario, most of the data circulating in the system are text or images. This will create enormous stress on the storage capacity of the system. For this reason and with the intention to increase the transaction throughput, there is a need for a radical change of the current version of the Blockchain technologies.

A most intuitive approach to increase transaction throughput is to increase the number of Blockchains by deploying mesh-chain or parallel chains. Figure 2 shows the difference in the structure between a single chain, mesh-chain and parallel chains. The IOTA Foundation has created a mesh-chain system, by use of Directed Acyclic Graphs (DAG) to increase the number of transactions several thousand times more than the classical Blockchain systems. Sia and Datum are Blockchain-based platforms where the users can store data in a cloud using single chain technology as the main Blockchain to manage the storage of the data. VeChain also uses single chain technology with slight centralization. It introduces verifier nodes to approve the data on the Blockchain.

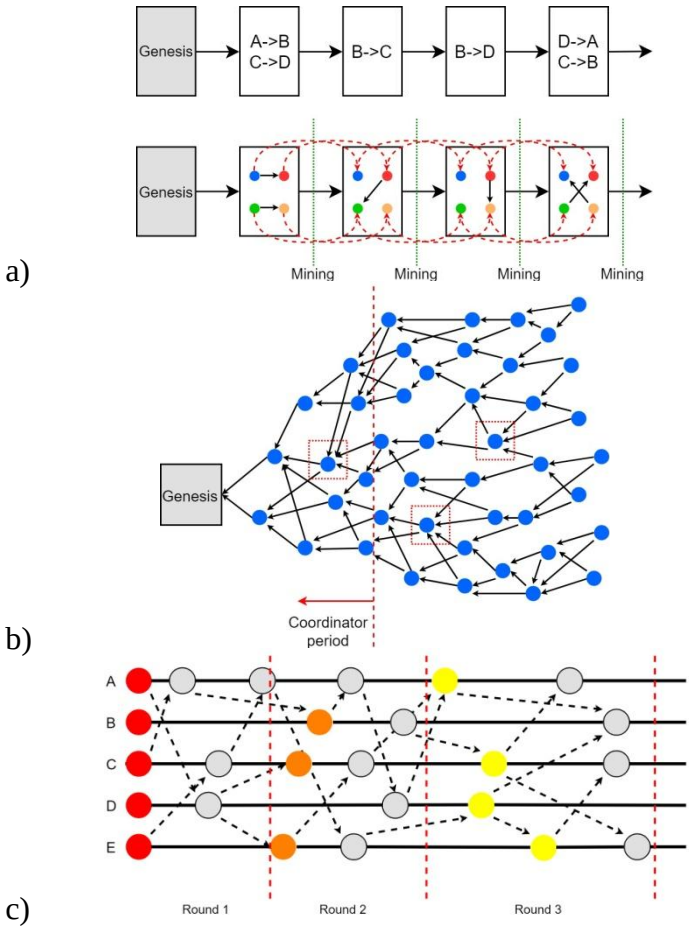

Fig. 2. Structural comparison between a) single chain, b) mesh-chain and c) parallel chains

Further ideas for non-financial Blockchains are the implementation of 2 tier network of Blockchains. The Blockchains will be divided into in-house and out-of-house Blockchain network for use in the smart home scenarios [19]. Another idea is the implementation of regional or countrywide segmentation [20] or implementation of individual Personal Blockchains to introduce the Self-Sovereign Identity [21] and manage personal records for a healthcare system. The ideas presented in [20] tackles several dimensions from the scalability problems in order to deliver worldwide healthcare system.

5. Conclusion

It is obvious that the Bitcoin and Ethereum networks showed their real potential, but also opened a lot of issues regarding Blockchain technology. There is no optimal single solution for every implementation scenario. The optimal solution for the future-proof Blockchain technology has to be adapted to the implementation scenario. The parallelism of the chains is the best suited for most of the scenarios as a future-proof approach. It will easily scale, modify, and communicate in-between the chains.

References

[1] S. Nakamoto, “Bitcoin: A peer-to-peer electronic cash system,” 2008.

[2] V. Buterin and others, “Ethereum white paper: A next-generation smart contract and decentralized application platform,” *Ethereum [Online resource]. URL: http://blockchainlab.com/pdf/Ethereum_white_paper-*

a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf, 2014.
[3] E. Androulaki, A. Barger, V. Bortnikov, C. Cachin, K. Christidis, A. De Caro, D. Enyeart, C. Ferris, G. Laventman, Y. Manevich, and others, "Hyperledger fabric: a distributed operating system for permissioned blockchains," in *Proceedings of the Thirteenth EuroSys Conference*, 2018, p. 30.
[4] L. Lamport, R. Shostak, and M. Pease, "The Byzantine generals problem," *ACM Transactions on Programming Languages and Systems (TOPLAS)*, vol. 4, no. 3, pp. 382–401, 1982.
[5] "Bitcoin Energy Consumtion." [Online]. Available: https://digiconomist.net/bitcoin-energy-consumption. [Accessed: Sep-2019].
[6] "Ethereum Energy Consumption." [Online]. Available: https://digiconomist.net/ethereum-energy-consumption. [Accessed: Sep-2019].
[7] D. Schwartz, N. Youngs, A. Britto, and others, "The ripple protocol consensus algorithm," *Ripple Labs Inc White Paper*, vol. 5, p. 8, 2014.
[8] "Litecoin." [Online]. Available: https://litecoin.org. [Accessed: Sep-2019].
[9] B. Xu, D. Luthra, Z. Cole, and N. Blakely, "EOS: An Architectural, Performance, and Economic Analysis," 2018.
[10] "Ethereum 2.0: A Complete Guide. Scaling, Part One." [Online]. Available: https://medium.com/chainsafe-systems/ethereum-2-0-a-complete-guide-3739a74be61a. [Accessed: Sep-2019].
[11] Y. Gao and H. Nobuhara, "A proof of stake sharding protocol for scalable blockchains," *Proceedings of the Asia-Pacific Advanced Network*, vol. 44, pp. 13–16, 2017.
[12] S. Martinazzi, "The evolution of Lightning Network's Topology during its first year and the influence over its core values," *arXiv preprint arXiv:1902.07307*, 2019.
[13] J. Poon and V. Buterin, "Plasma: Scalable autonomous smart contracts," *White paper*, pp. 1–47, 2017.
[14] J. Coleman, L. Horne, and L. Xuanji, "Counterfactual: Generalized state channels," 2018.
[15] S. Popov, "The tangle," *IOTA [Online resource]. URL: https://assets.ctfassets.net/r1dr6vzfxhev/2t4uxvsIqk0EUau6g2sw0g/45eae33637ca92f85dd9f4a3a218e1ec/iota1_4_3.pdf*, 2018.
[16] D. Vorick and L. Champine, "Sia: Simple decentralized storage," *Nebulous Inc*, 2014.
[17] R. Haenni, "Datum network: The decentralized data marketplace," *White paper v15*, 2017.
[18] VeChain, "VeChain: Development plan and whitepaper," *Whitepaper*, 2018.
[19] A. Dorri, S. S. Kanhere, and R. Jurdak, "Blockchain in internet of things: challenges and solutions," *arXiv preprint arXiv:1608.05187*, 2016.
[20] J. Karamachoski and L. Gavrilovska, "Toward scalable architecture for the next generation Blockchain-based Healthcare systems," *Balkancom 2019*, 2019.
[21] K. Wagner, B. Nemethi, E. Renieris, P. Lang, E. Brunet, and E. Holst, "Self-sovereign Identity: A position paper on blockchain enabled identity and the road ahead," *Blockchain bundesverband*, 2018.

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DESIGN AND IMPLEMENTATION OF OPTICAL SENSOR

Zhejno Ivanov

Abstract: The usage of several identical optical sensors of the "optical curtain" type to detect the presence of an object in one of several adjacent rectangular bands is considered. In the transmitter of these sensors the light source is an infrared LED. When the object interrupts the transmitter light beam, the photo receiver activates a relay.
An optical sensor of this kind is being analyzed. In the horizontal plane, the transmitter emits light in a too wide spatial angle, which prevents the simultaneous operation of several closely located sensors, because the light from the transmitters fall on the receivers of the neighbor sensors.
In the article a reduction of the optical curtain width by a suitable mounting design, is proposed.
Keywords: Optical sensor, optical curtain, design

1. Introduction

A device that performs different actions depending on the presence of people on some of the steps of a staircase in a building can be implemented using several identical sensors, one sensor placed on each step. Each sensor will send a digital signal to the device when there is a person on the step.

When choosing a sensor, safety, low cost, market accessibility and ease of implementation are taken into account. The literature describes the use of optical sensors for such purposes. These types of sensors belong to the group of presence sensors [2]. At each end of each step, there is an optical transmitter and a sensor receiver. When a passing object interrupts the light beams of the transmitter, a relay is activated in the photo receiver. This optical sensor is of the "light curtain" type and is widely used in security systems [3].

The device of two similar optical sensors used in practice was examined and some of their characteristics were measured. They have the required sensitivity and can detect an object as far as the length of the step. There are no problems when using a single sensor or multiple sensors mounted far apart. However, a group of closely spaced sensors interfere with each other and do not work properly because the transmitter light bundle is too wide and falls into the receivers of neighboring sensors. The narrowing of the spatial angle of the light beam can be realized in two ways:

- by changing the optical system of the sensor, which requires a change of the sensor construction;
- by placing additional apertures along the path of the light emitted and received, which can be done without altering the factory design of the sensor.

2. Construction and mounting design of the optical sensor

The choice of an optical sensor for the device was imposed by its price and dimensions. Structurally, the “light curtain” sensors consist of a transmitter module and a receiver module located in separate boxes. The transmitter contains one or more infrared light sources, typically with light wavelengths in the near infrared range of 900-1000 nm. The receiver is built with a semiconductor infrared light sensor that controls one or more contact outputs.

We will discuss two types of optical sensors of this kind, sold in our country. The ABT-20, ABT-30, ..., ABT-150 sensors create a two-beam light curtain - Fig. 1.

Fig. 1. A light curtain in front of a window

The transmitter transmits at a narrow angle from the horizontal and the vertical plane. According to catalog data, the distance at which an object intersects the beam is 20-150 m in open space, depending on the model. The sensor construction is shown in Fig. 2.

The boxes of the receiver and transmitter of the sensor are made of gray transparent plastic and act as filters that transmit only infrared light into the operating light spectrum [1]. Inside them are mounted 2 LEDs in the transmitter and 2 phototransistors in the receiver. There is an optical system composed of several lenses between the housing and the LED as well as between the housing and the phototransistor. The lenses narrow the angle of the light beams (typically 60^0) emitted by the LEDs, and in the receivers narrow the angle of light input into the photosensitive elements.

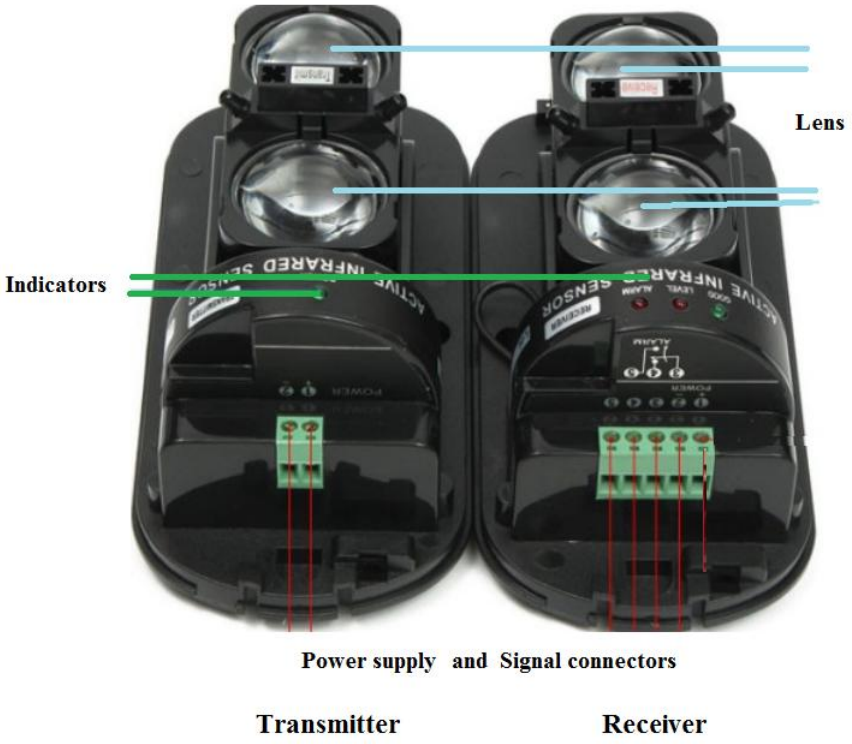

Fig. 2. Construction of the sensor transmitter and receiver

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emitted by the LEDs, and in the receivers narrow the angle of light input into the photosensitive elements.

To increase the sensitivity of the sensor, the LEDs in the transmitter do not emit light constantly, but on pulses with a carrier frequency of several kHz and a low duty cycle, which allows for several times higher pulse output power at low average power consumption. A bandpass filter is inserted in the receiver, passing only a frequency that matches that of the transmitted pulses from the transmitter. This greatly reduces the effect of ambient light on the operation of the device and significantly improves the signal / noise ratio.

Another widely used sensor of this kind is the CV PBS-20. It uses only one light beam to realize the light curtain. The construction of the sensors is similar to that described above. Dimensions, consumption and cost are smaller. In addition, these sensors operate at distances of up to 5 meters.

The appearance of the CV receiver and transmitter CV PBS-20 is shown in FIG. 3. and the construction of the open sensor is shown in Fig. 4.

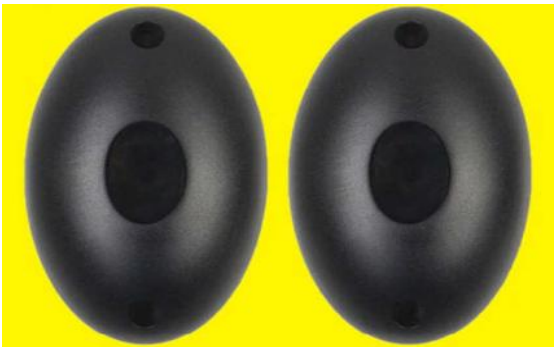

Fig. 3. Sensor CV PBS-20 exterior

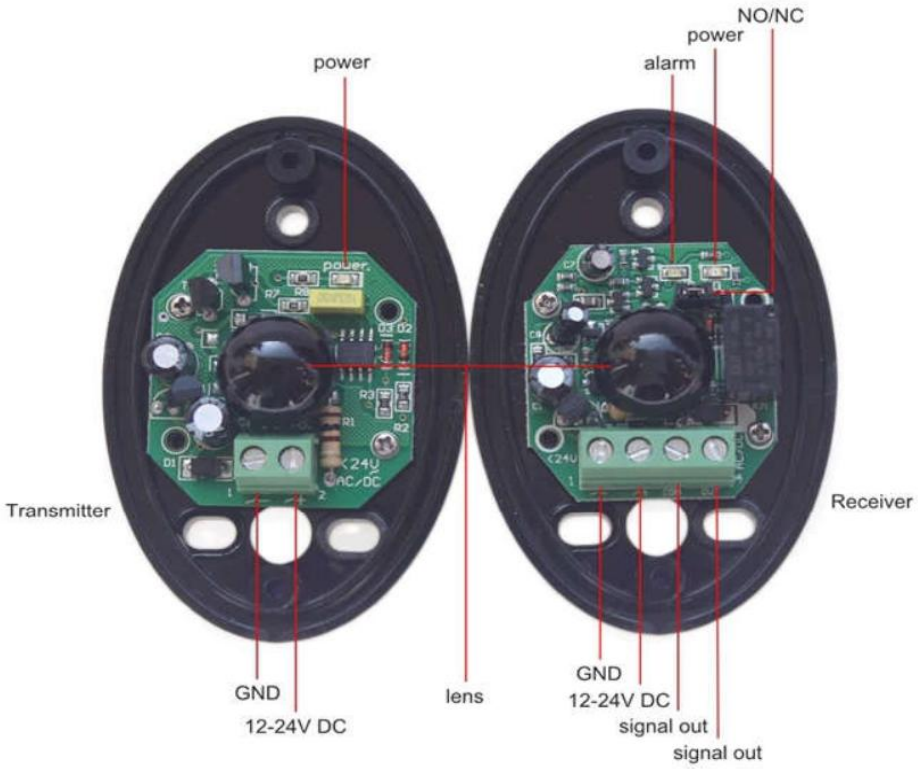

Fig. 4. Construction of optical sensor CV PBS-20

The radar formula (1) can be applied with some modification to the propagation of light in an optical sensor consisting of an optical receiver and a transmitter.

$$\mathrm{Pr} = \frac{Pt \cdot Dt \cdot Dr \cdot \lambda^2 \cdot \sigma}{64 \cdot \pi^3 \cdot r^4} \tag{1}$$

In the formula the radiation power is denoted by Pt and the input power of the receiver by Pr. Dt and Dr are the directivity coefficients of the transmitting and receiving antennas. λ is the wavelength. σ is the effective reflectivity of the object. r is the distance between objects [4].

For the optical presence sensors under consideration, the factor σ≈1 when there is no object between the transmitter and the receiver. Then all the transmitter's luminous power is directed to the receiver through the air between them. The minimum signal input power of the receiver required for the safe operation of the sensor depends on the technology used in the receiver elements and circuit design, as well as the ambient light noise. Due to mobility, low consumption, dimensions, weight and cost of the device, the power of the transmitting LEDs is limited. Thus, the design of the optical system of the transmitter and receiver makes a significant contribution to increasing the distance and reliability of the sensors. The ultimate goal is to get high directivity of the optical antennas. For this purpose, the transmitter should emit light sharply directed in a narrow spatial angle, and the receiver must perceive the emitted light only in a narrow spatial angle with a sharp maximum of sensitivity in the direction of the transmitter.

The sensors must correctly detect people on the steps of the building, when the length of the step of the building being 2.5-3.5 m and the width being 0.35 m. It was decided because of the lower cost and dimensions to use the CV PBS-20 sensors. The tests showed that the sensor responds correctly up to 4 m away, however, the transmitter of the sensor has a very wide radiation angle in the horizontal plane - more than 10^0, which causes the beam to fall into the receivers of the neighboring sensors and disrupt their normal operation. To reduce this angle, the transmitters and receivers of the sensors were mounted at one end of a 15 cm opaque tube and a 2 cm diameter diaphragm was installed at the other end of the tube.

The path of the light rays from the transmitter LED to the receiver phototransistor is shown in Fig. 5.

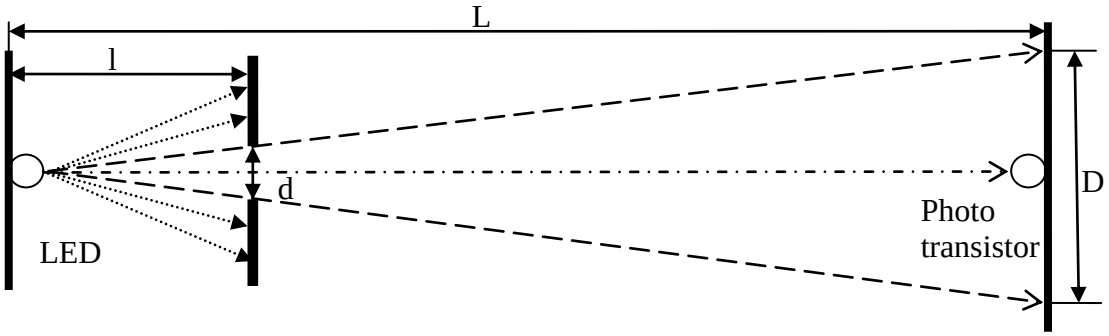

Fig. 5. Path of the light rays from the transmitter

If the receiver is not mounted behind the diaphragm, simply using triangles shown in Fig. 5 the following is obtained:

$$\frac{l}{L} = \frac{d}{D} \tag{2}$$

where l = 15 cm is the distance from the LED to the diaphragm at the end of the tube, L=300 cm is the distance between the receiver and the transmitter, d = 2 cm is the diameter of the aperture of the diaphragm and D is the diameter of the light spot on the receiver. From (2), D = 40 cm is obtained. If the receiver is placed behind a diaphragm with a diameter d, at the same distance l from it, due to the symmetry of the structure, the diameter of the light bundle decreases twice. Thus, the rays from

the transmitter sensors do not fall into the adjacent photodetectors if they are more than D / 2, ie 20 cm apart.

3. Conclusions

It has been experimentally found that 12 such optical sensors, mounted on the specified ladder design with a length of 3 m and a step width of 35 cm, operate independently of each other without interfering with each other.

The proposed method for eliminating the influence of closely located presence optical sensors with LEDs is a simple, low-cost solution that does not change the design of the sensor. It requires additional simple details. Sensors that use laser diodes and / or a more sophisticated optical system are more accurate, more stable, faster, and work longer distances, but are several times more expensive.

References

[1]. Fraden, J. Handbook of modern sensors. Physics, designs, and applications. 3-rd Edition. San Diego, CA., Springer, 2004. ISBN 0-387-00750-4.

[2]. Morris, A., R. Langari. Measurement and Instrumentation. London, UK: Elsevier Inc., 2012, pp 325-327. ISBN 978-0-12-381960-4.

[3]. Инженеринг ревю – 9/2009. Sofia, TLL Media Ltd., 2009, pp. 64-66. ISSN 1311-0470.

[4]. Червяков, Г. Технические системы охраны периметров и объемов. Мет. Пособие. Изд. 4-е. Москва, Таганрогский Государственный Радиотехнический Университет, 2005.

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ANALYSIS OF SOME ISSUES IN RISK ASSESSMENT FOR INFORMATION SECURITY

Petko G. Genchev, Milena N. Karova

Abstaract: In the modern world, the importance of information security is growing. This is why many organizations are building information security management systems. The basis of these systems is risk management. This article discusses some issues related to risk assessment in building information security management systems. An attempt has been made to summarize and unify problems and to clarify the causes of these issues. A more detailed analysis of some of the problems has been made and tasks have been formulated to eliminate or to reduce the cause is impact of the causes of the problems.
Key words: problems in risk assessment for information security.

АНАЛИЗ НА НЯКОИ ПРОБЛЕМИ ПРИ ОЦЕНКА НА РИСКА ЗА ИНФОРМАЦИОННАТА СИГУРНОСТ

Петко Г. Генчев, Милена Н. Карова

Резюме: В съвременния свят все повече нараства значението на сигурността на информацията. Това е причина много организации да изграждат системи за управление на сигурността на информацията. В основата на тези системи е заложено управление на риска. В тази статия са разгледани някои проблеми, свързани с оценката на риска при изграждане на системи за управление на сигурността на информациятаа Направен е опит за обобщаване и обединяване на проблемите, и изясняване на причините за тези проблеми. Направен е по-детайлен анализ на някои от проблемите и са формулирани задачи за премахване или намаляване на влиянието на причините за проблемите.
Ключови думи: проблеми при оценка на риска за информационната сигурност.

1. Introduction

In today's world, more and more organizations are relying on information technology to help them achieve their business goals, such as faster response to service or better quality. Therefore the security of information has an enormous importance for organizations. We need a systematic approach to risk management as regards security of information that help to define the requirements for information security and create an effective system of governance. The risk is the effect of uncertainty on objectives and the risk of information so security is often expressed in a combination of the effects of event information so security and probability of occurrence event. The subject of risk assessment is called an information asset, and an asset is anything that has value to the organization. The information assets in the management of security information consists of more than hardware and software. The information asset can be hardware, software, people, information, service and more. The risk assessment, both process and related techniques, offers an analytical and structured approach to the security status of the organization [2].

The purpose of this article is to provide a main overview of the issues involved in the construction and operation of Information Security Risk Management Systems (ISRMs). The review was made on articles on the topic in the last 7-8 years. The problems are structured according to the impact they have on the processes of construction and operation of the ISRM and the risk assessment activities as a basic element of the ISRM. Based on this comprehensive description of the problem there is an analysis of the problems and outlines proposals for solving more - important ones. Finally, conclusions are drawn about the nature of the problems.

The article is structured in 3 sections. The first section discuses and structures a large part of the problems related to the ISRM, the second section analyzes the more significant problem groups and proposes measures for reducing the problems. In conclusion, the main directions that should be addressed in order to facilitate the construction and operation of an ISRM system are outlined.

2. Main problems in ISRM

In this section we have describe some of the problems found in the publications of the last eight years. Taking into account some examples of building Information Security (IS) management systems, an unusual arrangement of the problems with their impact on the construction and organization of the operation of an ISRM system was carried out. This arrangement aims to support the structuring of recommendations for the activities facilitation for the ISRM construction, as well as to increase the efficiency of such system.

Issues related to data collection and processing:

- There is a lack of information on specific implementations of ISRM [1] ;
- Comprehensive, publicly available and reliable data on occurrences, impacts and their probabilities are not available. The use of such data would be useful in developing a new system for ISRM, as well as in cases where there is information accumulated in the organization, but it is good to compare it with industry average (benchmark) data to assess completeness, reliability and the relevance of inside information [10];
- It should be noted that the accumulated probability data do not reflect changes in event behavior [10];
- IS incident and threat statistics are not as accessible as other data. For some threats, such as the frequency of car accidents, there are extensive statistics; however, other threats are less understood due to lack of data. The insurers are not able to determine probabilities with the same security degree they can determine with traditional insurance lines. [9];
- With the inability to remain "ever vigilant", many organizations release important risk data [4];
- The collection of a large information amount needed for a good risk assessment poses the question of selection and quality assessment of the information collected [4];
- The decisions are often made without the necessary information and are instead based on management's assumptions [9];
- Lack of empirical research and good data [8];
- Lack of validation and testing. It turns out that IP control measures are being tested a little, leading to a lack of knowledge about the effectiveness of security measures. Some authors argue that security technology has low efficiency and developed testing methods are not strictly scientific or no mathematical proof [8];
- IS specialists are not sufficiently trained to design experiments and publish results [8].

Problems with risk assessment methods:

- Many evaluation methods are used. The Risk analysis methods depend on the asset nature and many valuation methods are used for organizations with many and varied assets. [5];
- There are no structures in order to assist organizations in determining the most appropriate risk analysis method [5] . In the literature there are more than 200 methods for risk management, and many approaches to ISP risk assessment are difficult to categorize by researchers and practitioners [10];

- There is no coherent method for measuring information security risks. Although many methods have been proposed, there are still shortcomings that impede the accurate assessment of IS risk . The Quantitative risk analysis methods may not include all the variables required. The qualitative methods tend to produce contradictory results [9] . There must be tools in place for IS professionals to perform quantitative risk analysis . There are difficulties in the probabilities calculation for quantitative methods , as well as the insufficient amount of accumulated data is available [8];
- The lack of validation and verification of existing methods. This problem is a consequence of the lack of empirical research and good data within the IS [8];
- It is argued that the subjective assessment methods and risk matrices add their own sources of error to the ISRM . For example, different people at different levels in an organization will evaluate the rocks differently. The Critics also state that the risk of low probability but a large impact is not the same as the risk with little effect, but with a high probability [8];
- There is an "over-sale" of methods that have no proven effect. The proliferation of such methods is financially stimulated and undermines the use of theoretical methods that work. [8].

Problems related to subjective factor:

- The selection of risk assessment methods is based on expert judgment and subjective judgment. This lack of objective quantitative practical guidance affects the prioritization and the vulnerable assets analysis [3];
- Risk assessment is a subjective analysis of costs and probabilities based on existing security measures. Methods have been developed that seek to add semi-quantitative value based on subjective judgments [9];
- People generally do poor risk assessment. The way we perceive risk is influenced by gender, age, race, emotional state, organizational rank, and more. In their judgments, default experts tend to underestimate risk and show overconfidence in their own judgments [8] . For procedural reasons, the valuer is usually simplified, otherwise it will be lost in detail [10];
- The reluctance to report incidents leads to a lack of knowledge of the system effectiveness. The People who happen to (or cause) accidents they can have many incentives to not report them [8];
- When there are a relying on managerial perceptions based on heuristics instead of facts, it can lead to a wrong organizational strategy and it increases industrial threats [9].

Performance issues:

- It is important to analyze the risk assessment effectiveness in organizations. Taking a risk assessment is an expensive business, it is normal to put the question "how effective is the practice of risk assessment in the organizations given the budget constraints for a typical IS ?" [1];
- The inability to prove that the ISRM works may be worse than there is no a system in place. The resources are spent on something that can have a zero impact on an organization's business. The failure to have a ISRM system can lead the organization to a worse state than it was before, such a management system was introduced [8];
- The Cost-effectiveness is needed .For example, the finding the benefits of a particular safety measure outweigh its costs does not rule out the possibility of even greater benefits being obtained from similar costs elsewhere [9];
- The Company constraints (price targets, prioritization) affect the performance. Taubenberger et al. [10] describe that in the system of ISRM implementation, the low and

several medium risks are not mitigated due to personal and company specific limitations such as perception, price targets and activities prioritization;

- The lack of a sufficient security budget is often an obstacle to achieve the desired level of IS protection [9];
- IS policies need to be read and understood by employees [9];
- It is not enough to implement security measures, they must be properly managed to be effective [9];
- The good implementation (installation and configuration) of security measures is required. The effective measures can be implemented in order to protect organizational information; however, they are installed and configured by people, which adds an error component to their performance [9].

Missed or undervalued sources of risk:

- The security should be seen as a process, not a product. For most part of people , the risk management is actually "Risk Identification" and they view security as a product, and not as a process [8];
- It underestimates the protection of reliability and security of business processes in an organization [8];
- The significant sources of risk are not taken into account during the risk management process. The are some examples: intangible assets such as knowledge; vulnerabilities arising from the complex relationships between multiple information assets; indications of malicious threats such as fraud, espionage or sabotage; lack of systematic and continuous training in IS-related incidents; inability to identify attack patterns or model complex or persistent attack scenarios [1] . It is not possible to be sure of the completeness and authenticity of identifying all threats and vulnerabilities. The underlying conditions are constantly changed and it leads to a behavior change and a severity of the threats and vulnerabilities [10];
- The co-occurrence of risks is not taken into account. The models used to determine risks and dependencies are bad because they do not take into account the co-occurrence of risks. In the current methods, the assessments are made on decomposed elements of the model. The organization is not addressed as a whole [10]. The correlations between risk situations can be different and varied, e.g. two or more risk events tie together and create a domino effect, etc. "cascading risk". Also there are situations when one risk damages more than one system at a time [8];
- The environmental impacts are not taken into account. In order to correctly identify events, probabilities and impacts, we must have a knowledge about the risk environment broad, the company and the outside world [10];
- The Intangible assets are skipped. If the intangible assets are not recognized, the valuation will be incomplete as they determine marginal social and non-technical dimension in the organization. There are analysts who claim that the current ISRM vision is too technical when it comes to assets. The problem is that the perception of assets influences the risk profile of the evaluated organization [8];
- The risk of human behavior is not adequately assessed. Their behavior is not objective or rational, it can follow personal interests or it can herd instincts as well as be prejudiced [10];
- Ignoring the risks associated with human actions at the expense of technological aspects (applications, devices, viruses and hacking). The fact that more attention is paid to the technical scope there is not a potential to analyze human factors risks, to neglect intangible assets and to cause organizational disconnection in both risk management and cost [8];
- Gaps are made at accepted risk. Very often, the effect on the security level or on the policies of companies do not take into account when the risk is accepted [10].

Vulnerability, Threats, and Impact Issues:

- Choice of many variants of vulnerability-threat pairs [2] ;
- The wrong choice of non-existent threat-vulnerability pairs can cause organizations to spend unnecessary time and money to prevent non-existent risk and neglect real weaknesses [2];
- An inaccurate assessment of the likelihood of a threat, the loss of a threat and the vulnerability to a threat can lead to a misunderstanding of the risks [9];
- An accurate quantification of potential losses from IS incidents becomes a problem for decision makers [9].

Organizational problems:

- It is necessary to use a common language for information security. It will facilitate the communication and it will help to achieve a common understanding of IS between companies. It will bridge the language gap that leads to confusion among the experts, people and organizations [8];
- Campaigning - there are no precise rules for the risk assessment pertinence[1];
- As the complexity increases with the diversity of dramatically growing information systems, the adaption to a particular model becomes more complex [6].

3. Analysis of the problems and suggestions to reduce the problems effect on the system efficiency

Analysis of problems related to data collection and data processing:

The lack of information on specific implementations of the ISRM provoke it very difficult to build such a system with own resources and specialists in the organization. This problem involves external expertise or the use of an information system that contains templates built on the basis of external experts. On the other hand, the lack of publicly available and reliable data on occurring events, impacts and their probabilities reflects the problem that such data are not properly collected in the organizations or, if available, they are not prepared for publication. To overcome the problems of current data collecting and management of storage and processing information, we propose to take the following organizational measures:

- It is necessary for each risk assessment to collect probability data, select and accumulate by type of vulnerability and threat. This will accumulate data to reflect to some extent the dynamics of event behavior;
- If there is a change in the risk assessment, it should be attempted to explain the change and add it to the vulnerability or threat statistics;
- All asset owners are required to keep current information on the operation of the assets they are responsible for. It is necessary to keep statistics on the non-fulfillment of this obligation;
- During the process of purchasing or forming a new information asset, or after that, it can look for technology and methods for performing IP verification tests on each information processing tool used;
- All information asset owners are familiar with the asset security testing technology and periodically undergo a documented refresher course;
- Each owner of an information asset must be obliged to periodically perform tests to prove the asset's IS . The frequency and testing technology should be defined in a specific document;
- Each asset owner must be obliged to produce and provide to his directors an asset security report, IS incidents, and a proposal to resolve the issues identified, together with a

financial statement. If necessary, the Asset Respondent should seek assistance from the IT department or from his / her supervisor to find external experts.

To reduce the negative effect of some of the **problems associated with risk assessment methods**, we propose the following measures:

- To alleviate the problems associated with many risk assessment methods, it is necessary to define and create an instrument that allows the assets to be automatically categorized and grouped by type of risk assessment method;
- For each risk assessment method used, it should be defined how the method is validated;
- It should be to determine, the necessary information to validate the effectiveness of the applied risk assessment method by experts and management and to collect this information on a regular basis;
- Determine the attitude of each asset to the organization's policies and business strategy by introducing a weighting factor that reflects the asset importance to the context of the organization (accounting for the impact of the risk on the asset separately);

The subjectivity problem is complex and multifaceted. It is not possible to fully overcome the subjective factor in risk assessment because it is a probabilistic assessment. To reduce the effects of subjectivism and to facilitate subjective decision we propose the following measures:

- Wherever possible, the range of options should be restricted;
- In order to reduce the effect of human misjudgment, it is necessary to make the selection or assessment by several persons independently of one another, using a single technology, and then to use an average or integer value depending on the weighting factor for each participant in the choice or judgment;
- To force the asset owner to report security incidents, a periodic asset security status report may be applied to remind the owner to pay attention to security and to detect bad faith. no reflection of the facts, if there are;
- It is necessary for the asset owners and external experts to prepare, at an appropriate level and in an appropriate volume, a risk level information for each asset and to provide it for use by the firm's management;
- With regard to informed decision-making, it is possible to arrange for the decision introduction should be taken after confirming the decision-maker's knowledge of the topic gathered information.

Effectiveness could be measured by the ratio of the information security invested to the value of any losses that an organization should be sufferred from a loss of security. In fact losses are, equal in impact and subject to more accurate determination. The question is what is the minimum amount of protection invested and what measures will be put in place to provide the necessary protection. It is also important what the losses (impact) will be if the safeguards are inadequate and an accident occurs . The following measures may be applied to increase the efficiency of the ISRM system:

- The effectiveness of the risk assessment will be improved if the collected and categorized assets security information is periodically scanned manually or automatically, after which the findings of the screening are stored in a database for further analysis;
- All inputs to reduce the level of risk must be accompanied by a methodology for controlling the use and efficiency of operation;
- The IS requirements must be applied in such a way that they do not allow for circumvention, even with the cost of inability to perform their duties. For example, the

inability to use the information resources if the access password has not been changed within the specified time;

- When introducing new data processing tools, it is necessary to define and describe all the features of the installation , as well as more responsible settings and modifications, so that they can be subject to periodic monitoring during operation;
- We need to introduce automatic control means of compliance with company requirements in terms of IS, where possible and necessary, with the results being announced at higher levels of management.

In order to reduce **the gaps and underestimate the sources of risk**, the following should be considered:

- Information on all information security incidents should be monitored and collected;
- Interviews with the owner of each asset and other professionals relevant to the asset should be conducted periodically . Draw on these interviews to draw conclusions about trends and the emergence of new vulnerabilities or threats;
- The information collected and processed must be made available to experts for analysis and identification of attack patterns or for modeling complex or persistent attack scenarios;
- Determine the ratio of the asset to other assets . Who is influenced and influenced by IS. Determine and agree with management the degree of influence (in%);
- When calculating the risk value for each asset, take into account the impact of the affected assets, taking into account the% impact. The final level of risk for an asset should be a function of the vulnerabilities and threats to that asset plus the impact of the inherent risk of interacting with other assets;
- To monitor and record any change in the context of the company . With a new element in context, evaluate its impact on which assets and how it affects;
- In defining the intangible assets, participate a representative of the organization's management to ensure the completeness and accuracy of the inventories;
- All intangible assets should have the same description and information security, as well as all tangible assets. If necessary, introduce a technology to align the collection and processing of information on intangible assets in a uniform manner with tangible assets;
- Introduce special measures for the control and organization of human activities , in order to avoid unforeseen and unregulated reactions;
- For each asset , develop and maintain a record of the level of risk and the measures applied to reduce the level of risk, regardless of what the original levels of risk were and whether they were adopted;

To overcome **vulnerability, threat and impact issues**, we offer:

- If external lists of descriptions of vulnerability-threat pairs are used , those lists must be made available to the organization for control and future use in the operation of an asset or in the context of a company change;
- The estimation of the probability values for each pair should be made by several valuers who are either directly related to the asset, or indirectly related to the asset, or are experts in the field, or are in a responsible position in the organization.

4. Conclusion

The review and analysis of the problems leads to the conclusion that the main part of the problems is related to the underestimation, failure to fulfill or circumvent the recommendations and requirements, which give the standards for the implementation of the ISMS and the ISRM . Various

reasons influence the failure to comply with the organizational and technical recommendations and requirements of the standards. Some are related to financial reasons and others to incompetence and subjective reasons. It is necessary to conclude that in order to increase the efficiency of the introduction of the ISRM system, it is necessary to introduce the means to discipline the staff and to introduce stricter responsibilities at all levels of management.

Many of the problems found are due to the same causes, but they affect different elements or processes in the ISRM. This means that removing a group of causes will solve several problems at once.

The initial review of the problems suggests that most problems are related to the need to introduce a single tool for collecting and processing information for the construction, processing and adaptation of the system to a rapidly changing environment. Closer analysis leads to the conclusion that a large group of problems are related to the reporting and consideration of complex interconnections of information, organizational, technical and subjective nature. In all likelihood, this will be a software product in which these relationships and influences need to be properly defined, accounted for and processed. There is a need for a thorough and precise definition of the necessary requirements to f functionalities you need to realize the product. It must support the accumulation of operational information to monitor the performance of responsibilities introduced to systematize and provide the necessary information to make informed decisions and to store these solutions and make them available for information and execution of employees. On the other hand, such a software product should allow for the introduction of settings that determine the monitoring and reporting of interrelations and influences between individual elements of the ISRM. These settings should be able to change dynamically, thus providing adaptation to the changing environment. Last but not least, the program must exercise hierarchical, authorized access to its resources while protecting its stored information.

References

[1]. Webb J., A. Ahmad, S. B. Maynard, G Shanks, A situation awareness model for information security risk management. //Computers & Security,Volume 44, July 2014, Pages 1-15.

[2]. Yu-Chih Wei, Wei-Chen Wu, Ya-Chi Chu, Performance evaluation of the recommendation mechanism of information security risk identification. // Neurocomputing, Volume 279, 1 March 2018, Pages 48-53.

[3]. Nadher Al-Safwani, Yousef Fazea, Huda Ibrahim, ISCP: In-depth model for selecting critical security controls. //Computers & Security, Volume 77, August 2018, Pages 565-577.

[4]. Palaniappan Shamala, Rabiah Ahmad, Ali Zolait, Muliati Sedek, Integrating information quality dimensions into information security risk management (ISRM), // Journal of Information Security and Applications, Volume 36, October 2017, Pages 1-10

[5]. Palaniappan Shamala, Rabiah Ahmad, Mariana Yusoff, A conceptual framework of info structure for information security risk assessment (ISRA), // Journal of Information Security and Applications, Volume 18, Issue 1, July 2013, Pages 45-52;

[6]. Suleyman Kondakci, Analysis of information security reliability: A tutorial, // Reliability Engineering & System Safety, Volume 133, January 2015, Pages 275-299

[7]. Ana Paula Henriques de Gusmão, Lúcio Camara e Silva, Maisa Mendonca Silva,Thiago Poleto, Ana Paula Cabral Seixas Costa, Information security risk analysis model using fuzzy decision theory, // International Journal of Information Management, Volume 36, Issue 1, February 2016, Pages 25-34

[8]. Gaute Wangen & Einar Snekkenes, A Taxonomy of Challenges in Information Security Risk Management, //https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2483955/Wangen+1+Taxonomy.pdf?sequence=2

[9]. Richard G. Taylor , Potential Problems with Information Security Risk Assessments, // Information Security Journal: A Global Perspective, 24:177–184, 2015
[10]. Stefan Taubenberger, Jan Jürjens, Yijun Yu, Bashar Nuseibeh, Problem Analysis of Traditional IT-Security Risk Assessment Methods – An Experience Report from the Insurance and Auditing Domain // HAL Id: hal-01567605, https://hal.inria.fr/hal-01567605, Submitted on 24 Jul 2017

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TECHNOLOGY, QUALITY AND INNOVATION - KEY ASPECTS OF COMPETITIVENESS OF INDUSTRIAL ENTERPRISES

Krasimira Dimitrova

Abstract: This study focuses on key aspects of competitiveness - technology, quality practices and innovative approaches in industrial enterprises. Their role is essential for the implementation of company policies aimed at using innovation to enhance the competitiveness. This role is necessary and important for investment in innovation and business decisions making. Quality management integrated in innovation focuses on two factors of competitiveness: controlling the risks of failure caused by disruption of past manufacturing and consumer practices and optimizing market access for innovation. This study analizes the opportunities for the successful integration of modern technologies and quality into the innovation process in order to ensure of industrial enterprises the most cost-effective competitiveness over time.
Keywords: Technology, Quality, Innovation, Innovation process, Competitiveness, Fourth Industrial Revolution, Global Competitiveness Index.

1. Introduction

This survey is in the range of a research project of Department of Industrial Management of Technical University of Varna numbered NP14/2019, financed specifically by the state budget and aims to analyze the links between technologies, quality and innovation and their impact on the competitiveness of industrial enterprises. Teachers and students from the department are involved in the project. This publication looks at some basic theoretical aspects of the competitiveness of industrial enterprises in Bulgaria in the face of the ever-expanding opportunities of information and communication technologies and their impact on business.

Creating innovation is a process that requires collective knowledge and experience. Technologies by their very nature can also be seen as products or outputs. Quality systems provide the conditions to produce the necessary products that meet predefined criteria, directly related to innovation and aimed at meeting the needs of consumers. The relationship between technology, innovation and quality is based on creating new value and maintaining the ability to create it in the future. Companies seeking competitive advantage must be able to effectively manage their ideas. Ideas management focuses on identifying and selecting relatively few ideas with exceptional quality from a flow of raw concepts. [1]

In January 2018 the 48th Annual World Economic Forum in Davos, Switzerland has officially introduced the name Fourth Industrial Revolution (4IR). It is clear that not only this revolution has not an alternative, but it will undoubtedly change the future prospects of countries and peoples, the balance of power globally and the map of the world. [9]

With the 4IR, humanity has entered a new phase. 4IR has become a reality for millions of people around the world, creating new opportunities for businesses, governments and individuals. The World Economic Forum introduces the new Global Competitiveness Index GCI 4.0, based on 40 years of experience in benchmarking the engines of long-term competitiveness. Having conceptualized 4IR, World Economic Forum contributes to global thinking and policy development to integrate the concept of GCI 4.0 into the definition of competitiveness. The index integrates well-established aspects with new and emerging levers that drive productivity and growth. It emphasizes the role of human capital, innovation and flexibility as defining features of economic success in the EU. It calls for better use of economic development technologies, but also warns that this is only possible as part of a holistic approach with other competitive factors and offers objective, data-driven analysis for impartial, future-oriented and rational policies and solutions.[9], [7]

The results of GCI 4.0 suggest that most economies are far from "borderline" competitiveness - an aggregate ideal across all competitiveness factors. In the face of rapid technological change, political polarization and fragile economic recovery, competitiveness is the definition, evaluation and implementation of new ways of growth and prosperity. One of the determining factors for long-term growth and higher incomes is productivity. The new GCI 4.0 sheds light on the emerging set of factors critical to the performance of the 4IR and requires a new tool to evaluate them.[9], [7]

2. New tools for understanding and assessment of competitiveness

New concepts. With the inclusion of new concepts for data collection, GCI 4.0 provides new and more nuanced ideas for factors that will increase in importance over the course of 4IR: human capital, innovation, sustainability and flexibility. These factors are reflected in an entrepreneurial culture, companies that embrace innovative ideas, multilateral cooperation, critical thinking, social trust and complement with more traditional components such as Information and Communication Technologies (ICT) and physical infrastructure, macroeconomic stability, intellectual property, education.

New metrics. GCI 4.0 introduces a new progress rating from 0 to 100. The limit 100 corresponds to the maximum value for each indicator.

12 pillars of competitiveness. There are totaly 98 indicators in the Competitiveness Index obtained from a combination of data from international organizations and the World Economic Forum Report. They are organized into 12 pillars in GCI 4.0 (Fig. 1) [7]

Fig. 1. The Global Competitiveness Index 4.0 2018. [7]

For the second half of the 20th century, the path of development seems relatively clear: lower-income economies could be developed through progressive industrialization, using low-skilled labor. In the context of GCI 4.0, the sequence has become less clear as technological and capital costs are lower than before, but their successful use relies on a number of other factors. And a strong performance in one pillar cannot compensate for a poor performance in another. Investing in technology without investing in digital skills will not bring significant productivity benefits. To increase competitiveness, no area can be overlooked. [7]

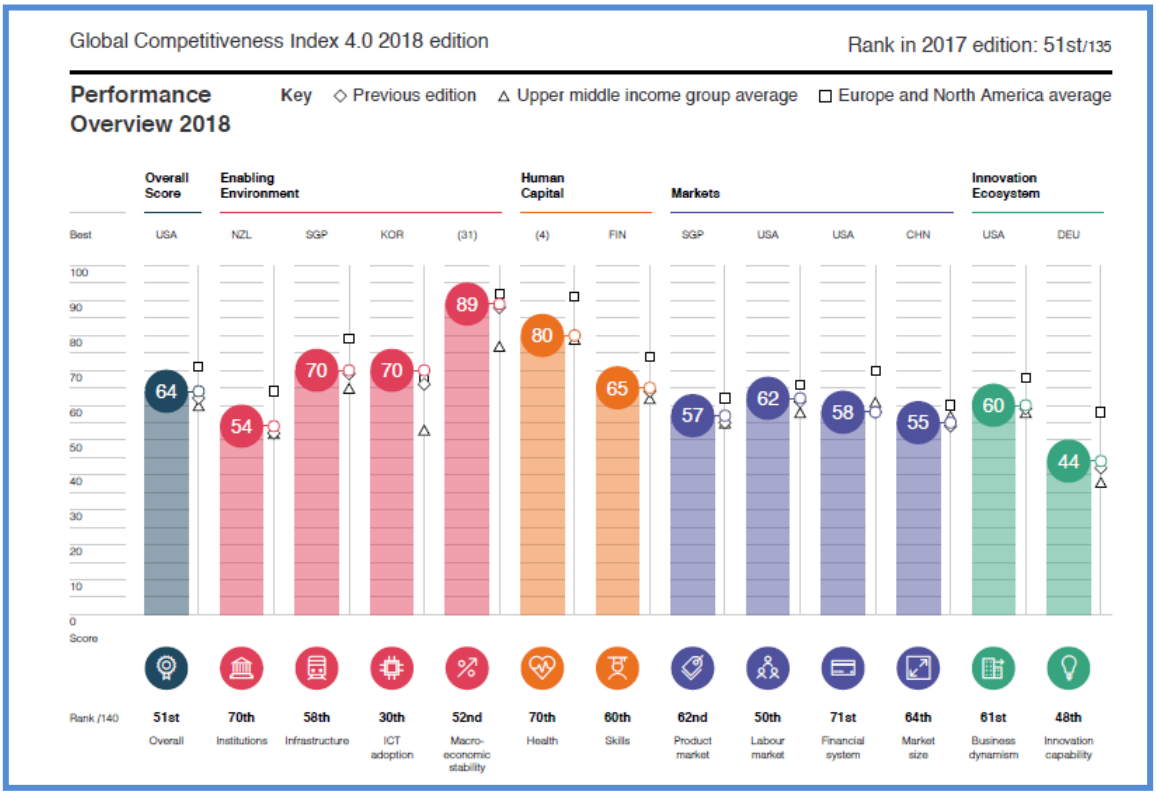

Fig. 2. Global Competitiveness Index 4.0 for Bulgaria for 2018. [7]

Technology

4IR is different from the previous industrial revolutions in the way it is based on the merger of technologies and the increasing harmonization and integration of research fields. Almost every new development in every field already uses digital capabilities. Advanced robots will not exist without new approaches to artificial intelligence that depend on digital systems and computing power. The digital and physical worlds also collide in areas such as autonomous vehicles, 3D printing etc. Advances in sensors enable robots and autonomous systems to better understand and respond to their environment and engage in a broader range of tasks beyond the factory where they have been the most widely used historically. These systems can now access information remotely through clouds and connect to each other to share information and learn collectively. As the next generation of robots emerges as an element of the Internet of Things (IoT), there will be an increasing emphasis on human-machine collaboration. [9]

The physical and biological worlds merge partly thanks to the creation of new materials that are intended to imitate the biological world. The discovery of new classes of recyclable, thermoset polymers, called polyhexahydrotriazines, is an important step towards a more sustainable economy. New materials are now routinely used in medical implants, tissue engineering and the creation of artificial organs, and 3D printing is increasingly being used to create custom structures. Biological and digital worlds also overlap in the form of sensors used to monitor personal health and behavior, in genetic engineering, as well as to understand and influence brain activity. Progress that could once be limited to digital systems, such as the application of cryptography to blockchain technology to create programmable, secure and widespread records, is now widespread in the real world. [9]

The progress in computer technology, sensors, mobile connectivity, artificial intelligence, robotics, 3D printing and advanced materials are changing manufacturing systems. New business models based on platforms and evolving capabilities to offer new services rather than simply deliver products will change the way manufacturing companies operate.

Information technology is at the heart of innovation, and advances in the industry are affecting every business. The digital communications industry is facilitating unprecedented levels of

global Internet usage, online social interaction and financial inclusion. As the industry transforms, effective policies and regulation that support business can increase productivity. At the same time, the industry needs to be open to new models of collaboration and governance to better meet the challenges, such as privacy and growing infrastructure requirements.

4IR has brought about changes in the business model that will significantly disrupt labor markets. New job categories will appear, while others will disappear. According to the report on the future of jobs at the World Economic Forum for 2016 most industries will require new skills from their workers, and 7.1 million jobs will be lost by 2020. [6]

In 2016 The Organization for Economic Co-operation and Development (OECD) reports a rapidly developing trend of complete replacement of workers with computers. OECD points out that even mid-level jobs that require some skills are usually routine and thus potentially automated. This deletion of mid-level jobs, coupled with the expansion of low-skilled jobs and increased demand for highly-skilled workers, leads to an increase in social polarization. [9]

Quality

The processes of globalization are changing the modern understanding of the management system - modern management is becoming increasingly involved in market relations, models of management and organizational forms are changing. The introduction of innovations gives an advantage and an opportunity to modernize production structures and services, to improve products and technologies, and to increase their international competitiveness. The long-term goals of innovation are to increase international competitiveness, stimulate the use of science, technological solutions and organizational innovations in business. [1]

Given the dominance of the technological and turbulent environment with unprecedented customer expectations, the development of quality management in the age of Industry 4.0. has and will have an increasing impact on the economy, decision-making models, business models, human and technological perspective.[12]

Technology is a broad concept in the context of innovation and encompasses the processes by which an organization transforms labor, capital and information into products that deliver value to customers and other stakeholders. This technological concept extends beyond engineering and manufacturing and covers marketing, investment and management processes. It also includes quality management.

Technological innovations provide virtually unlimited opportunities to improve the quality of products and services. This includes innovations in information technology, biotechnology, nanotechnology, energy technology, social technology and more. The capabilities of new IT solutions are creating new ways of working in processes and doing business through networks or ecosystems of organizations, which is also a challenge from a quality management perspective.[12]

The contribution of quality is mainly focused on ensuring that innovation will:

- create and strengthen the desired links between the company and the target market sectors;
- create the expected purchase value of products and services that integrate innovation by stimulating some of the perceptions that customers have about those products and services;
- provide the resources that internal and external investors and producers of products or services will require to produce them;
- meet the regulatory and security requirements of the clients and institutions of the countries in which these market sectors are located.

Innovation

The innovation process is the materialization of new ideas, guided by the projection of a very uncertain future in terms of the methods of use and the return on investment that they will produce.

Innovation is defined as ways to update, change and improve internal processes, production techniques and management methods. Innovation must meet certain criteria to be successful, including meeting customer needs, meeting cost and return on investment requirements, improving employee satisfaction and product quality. Innovation helps to bring new concepts, knowledge, products, services and processes into organizations and the external market.

Innovative products are the ones that replace or upgrade the current ones. They provide new features or other benefits that allow users to work more efficiently and cheaply.

Process innovation is about finding better ways to get things done. Compared to product innovation, there may be no new ingenious idea to build, test, fund, sell, launch, and service. In some cases, the product is a product with a long product life cycle. Although the product itself can change very little, although innovation is still important for competitiveness and long-term success. Therefore, the processes involved in manufacturing and delivering a product are those where changes can continue to offer more value to customers and stakeholders.

While innovative new products and services, along with new manufacturing and delivery processes, are often used to improve organizational performance, the entire business model can become obsolete and inefficient, requiring a dramatic change in the thinking of executives. The need for innovation in the business model is often driven by the increasing need for flexibility in the business structure, which in turn is driven by the increasing speed of market change.

Innovation adds value and a successful innovative solution can improve the process and its outcome. But innovations and improvements are often mentioned in tandem. Not all improvements are innovations, while most innovations are improvements. However, there are some innovations that are not improvements. The relationship is shown on the Fig. 3.

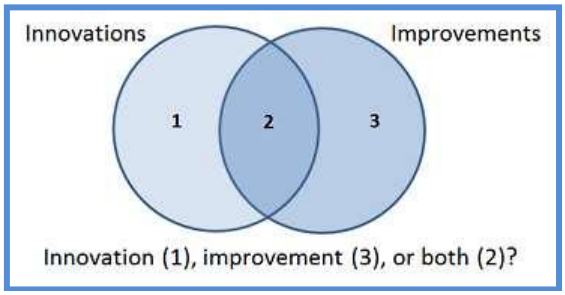

Fig. 3. Relationship between innovation and improvement.[9]

There is often a distinction between breakthrough innovation and incremental innovation. Both types of innovation are valuable to organizations. An organization can benefit greatly when it is skilled in both breakthroughs and incremental innovation. Much of what applies to quality technologies can generally be characterized as incremental innovation. However, innovations, which may not be technologically significant enough to warrant much attention, can still be extremely economically important. Both types of innovation show benefits for organizations and customers. Every introduction of an innovation into a product or service brings with it a number of uncertainties that can lead to different risks of failure. In order to accept a commitment to significant resources in this type of project, it is necessary to include in their management an effective regulatory system that is able to identify these risks as quickly as possible in order to avoid their negative impact, using the full creative potential of the team. This is the natural role of the quality system integrated in the innovation process. This is about finding and maintaining that "dynamic equilibrium" between making the most of value creation opportunities and controlling the risk of failure.[10]

This paper reviews some theoretical linkages between quality and innovation and the way they could be applied and inter-applied to ensure the most cost-effective competitiveness over time from the creation of innovation to the production system for the products and services that will benefit it. An organisation can take a quality approach towards innovation and an innovation

approach towards quality. These specific quality processes are known as "competitive quality processes".

The innovation process consists of the following steps:

- Deciding to promote new ideas to support the company's progress;
- Creating an idea that can respond to the needs of society;
- Brief characterization of products or services that could benefit from the innovation;
- Identifying potential customers for these future products or services;
- Characterizing the future uses of products or services that would incorporate innovation;
- Creation of experimental projects that present the idea as accurately as possible;
- Conducting initial tests for the feasibility of future products or services;
- Deciding to initiate prospective studies on how to use the idea for the benefit of the company;
- Conducting prospective studies on the possible socio-economic applications of innovation and its impact on the company and its position;
- Making a decision to guarantee the company's ability to mobilize the necessary resources, internally and externally, to fully implement its innovation process;
- Identification of future stakeholders in the innovation project;
- Conducting studies on the nature and feasibility of exchanging with future project stakeholders required for its full implementation;
- Solving contractual issues with these stakeholders and building a processor to carry out the innovation process;
- Building a processor responsible for implementing the innovation process and external communication network;
- Deciding on the gradual design of projects that give a more accurate idea of the idea;
- Ggradual design of these projects in order to accurately represent the innovation configuration;
- Deciding to conduct prospective studies on the socio-economic impact of future products and services that will include innovation;

How can the world achieve economic growth while tackling climate change and other challenges related to natural resources? The global environment and economic security are inevitably linked to increasing greenhouse gas emissions, environmental degradation and the depletion of natural resources, which jeopardize sustainable growth and existing business models. According to the International Labor Organization's 2016 report till this time, 200 million people were unemployed globally, and by 2020. More than 300 million additional jobs are needed to provide livelihood for the next generation of workers. In a 2013 report Carl Benedict Frey and Michael Osborne from University of Oxford estimate that in the next decade or two, almost half of all professions may be affected by automation and technology. Therefore, new approaches to job creation and skills development are urgently needed in both the private and public sectors. [2]

Manufacturing is experiencing a decade of stagnation in productivity and fragmentation of demand; thus, innovation is delayed. Where innovation in the fourth industrial revolution has taken place, there is an unprecedented increase in efficiency with minimal relocation of workers. This demonstrates how advanced technology thinking can create a better, cleaner world through new levels of production efficiency. The technologies of 4IR can transform the nature of the work itself by upgrading skills and engaging workers with minimal changes.

Three technological mega-trends are emerging - connectivity, flexible and intelligence automation. They are the main drivers of the fourth shift in the paradigm of the Industrial Revolution in manufacturing:

- **Connectivity** - creates connections between discrete network nodes, increasing visibility;

- **Flexible automation** - includes response, automation and remote movement mechanisms;
- **Intelligence** - automates the recognition and translation of decision-making events.

The adoption of technology on a large scale can have a radical impact on organizations. Early adoption of technology is crucial, as companies waiting to pass the risks miss out on a large share of the benefits. Leaders of early-stage companies, instead of waiting for technology and transition costs, will reap the greatest benefit. Thus, the most important factor here is related to the competitive advantage of leading players, far exceeding the higher transition costs and capital costs associated with early adoption. [5]

3. General characteristics of the 4IR

Diffuse technologies in geographical regions and SMEs - the full benefit of 4IR in manufacturing can only be realized if the value chains and production ecosystems are fully transformed, including all small and medium-sized enterprises, which contribute 50-60% of value, added to the OECD countries. Therefore, companies need to spread the technologies of 4IR across their entire production network and include emerging economies. This will not only improve the overall results, but will also distribute the knowledge more evenly.

Large and Small Enterprises. Innovation is accessible not only to large organizations but also to small and medium-sized enterprises (SMEs) that can have transformative impact by focusing on pragmatic solutions that do not require large investments.

Industrial revolution technologies - The world faces a significant challenge with regard to climate change, with a recent report of Intergovernmental Panel on Climate Change (IPCC) stating that emissions must be reduced by 45% by 2030 in order to stay below 1.5°C. Factories must therefore use the technologies of 4IR to improve their energy efficiency, increase production and reduce waste and emissions, while increasing overall competitiveness. [13]

Production system innovation. Companies are expanding their competitive edge through operational excellence. They aim to optimize their production system, increasing productivity and quality of their operations. They usually start innovating at one or more manufacturing sites and then deploy them.

End-to-end value-added chain innovation. Companies start new businesses by changing the economics of operations. They innovate throughout the value chain by offering new or improved value propositions to customers through new products, new services, more customization, smaller batch sizes or significantly shorter lead times. Businesses remain focused on innovation and first transform the value chain, then scale their learning and capabilities in other parts of the business.

Qualitative leap from the industrial to the post-industrial paradigm - 4IR can be described as a set of new technologies that connect the physical, digital / biological world and affect everything - economy, technology and society as a whole. This revolution includes "emerging technological breakthroughs" in areas such as new energy - hot and cold fusion, artificial intelligence, robotics, IoT, autonomous vehicles, 3D printing, quantum computers, new information technology, biotechnology and nanotechnology. On the 4IR platform, humanity is entering the post-industrial paradigm; [9]

Additive Manufacturing vs Subtractive Manufacturing - Production is based on the so-called. "Manufacturing production." The latter is a fitting name to describe the technologies that build 3D objects by adding a layer to the material, whether the material is plastic, metal, concrete, or one day, and human tissue. This type of technology is characterized by the use of computer and 3D modeling software (Computer Aided Design - CAD), machinery and coating materials. After a CAD sketch is created, the triple-printer apparatus reads CAD data and defines layers down or adds consecutive layers of fluid, dust, sheet or other layer to layer to produce a 3D object. The term Additive Manufacturing encompasses many technologies, including subgroups such as 3D printing,

Rapid Prototyping (RP), Direct Digital Production (DDM), production of layers and production of additives. This is quite different from the so-called. 'Production-taking' characteristic of the industrial paradigm where, for example, if a workpiece is taken, it is cut, drilled, lathed, sanded, etc. until the necessary product is obtained;[8]

New energy - it is primarily about the so-called. "Hot" and "Cold fusion", energy from renewvable power sources etc.

Nanotechnology emerged in the early 1980s. The object of nanotechnology is the study and manipulation of various nanomaterials. As a result of the difference in scale, most of the nanomaterials (semiconductors, metals, etc.) form specific physicochemical properties that differ from those of the same materials in their traditional use. These different properties are used to create new devices, devices, technologies, methods of diagnostics and treatment in medicine and others. Often nanotechnologies are called "closing technologies" because their use can lead to a drastic downsizing or closure of even entire industries, such as the so-called "technology shutdown". nanomaterial zipper anti-corrosion coatings that make it possible to make timeless products, ie those that do not corrode; [8]

The Internet of Things (IoT) is a network of physical devices, vehicles, household appliances and other items, with integrated electronics, software, sensors, drives and network connectivity that allow these sites to connect and exchange data. Each is uniquely identifiable through its built-in computing system, but is able to interact within the existing Internet infrastructure. Experts estimate that by 2020 it will consist of about 30 billion objects. The Internet of Things allows objects to be recognized or remotely controlled in existing network infrastructures, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in increased efficiency, accuracy, and economic benefits in addition to reduced human intervention. [8]

When technology is complemented by sensors and actuators, technology becomes an example of a more general class of cyber-physical systems, including technologies such as smart grids, virtual power plants, smart homes, smart vehicles and smart cities. "Things", in the IoT sense, can relate to a wide variety of devices, such as cardiac implant implants, farm animal bio-transponders, live animal feed streams in coastal waters, cars with built-in sensors, DNA analytical monitoring devices for environmental / food / pathogens or on-site devices that assist firefighters in search and rescue operations. IoT is an "inseparable combination of hardware, software, data and services." These devices collect useful data using various existing technologies and then autonomously transmit data between other devices.

Artificial Intelligence (AI), also known as "Machine Intelligence" (MI) is the intelligence displayed by machines, as opposed to Natural Intelligence (NI), shown by humans and animals. In computer science, AI research is defined as the study of "smart agents": any device that perceives the environment and takes actions that increase its chances of success in achieving any goal. Objectives of AI:

1. Forming arguments and solving problems;
2. Knowledge presentation;
3. Planning;
4. Training;
5. Language translation;
6. Perception;
7. Movements and manipulation;
8. Social intelligence, ie use for forecasting;
9. Creativity;
10. General intelligence;

The new industrial paradigm needs a new type of human factor in which creative and innovative potential, self-motivation and self-management are key. At the same time, such a

revolution has led to massive layoffs of people employed. This will create serious social problems with numerous, diverse and long-term consequences for the development of human society from a political, economic and cultural point of view if the current social organization of labor is preserved.

4. Bulgaria faces the challenges of 4IR

Bulgaria faces the challenge of the vital need to change the industrial to the post-industrial paradigm, i.e. with a new technological mode of reproduction in extremely bad form. High technology in the face of the electronics industry has disappeared, as have many others. The so-called "Information services" are mainly at the expense of the so-called Outsourcing which does not create sufficient conditions for sustainable dynamics for the country. Even the relatively high growth rates of over 3.5% in recent years are the result of factors related to today's turbulent environment, i.e. they are also subject to strong fluctuation and instability. In the last two decades in Bulgaria, no projects have been implemented for the construction of a fundamentally new large industrial enterprise, of new power plants, of ships. Road infrastructure is in poor condition. It is undoubtedly very difficult to create a favorable economic environment in a situation where companies are sunk in debt, with overdue claims exceeding BGN 10 billion. This is the corruption, the gray and "dark" sectors, the criminalization of business life. Today Bulgaria is at a crossroads. The future and the decades to come will depend on what direction the country will go now in the coming years. And that means whether our country will be able to integrate dynamically enough into the emerging global system of post-industrial division of labor. [8]

5. Conclusion

Overcoming conventional business management thinking requires businesses to respond quickly to new trends and focus on products, processes, results and customer value. Otherwise, few companies that support the traditional business approach could survive in today's dynamic business environment. Integration of processes becomes absolutely essential for the business, as well as the need for new methods to help organizations become more efficient and competitive. Today's network economy brings a new and expanded scope of business activity. The use of new technologies for trading platforms and collaboration requires the introduction of innovative ways to achieve the desired effect. [3]

New production concepts require fundamentally new ways of technological construction. The implementation of global information networks allows intensifying production and significantly improving the quality of the product being manufactured. Special attention is paid to new software products and their compatibility with the requirements of modern industrial reality, such as digitalization, artificial intelligence and virtual reality. The place and role of Concurrent Engineering (CE) in the new world of smart technology is not only a subject of research, but also a huge challenge for its practical utility. The development of scientific and technical progress led to such technologies by means of which it is possible the application of modern organizational forms in the transfer of information as well as for coordination and permanent control of the stages of development and manufacturing. This development is characterized mainly by improvement of hardware and software products for transfer of information - computer networks. According to its scope of activities they are local and global. The development of global information networks enable the creation of virtual manufacturing where all exchanges of data, results and technologies is based on the principles of CE. The role of CE for optimization of resources in real time and needs of flexibility of the engineering process are intertwined with the capabilities of totally integrated automation. Cooperation between machine-web, machine- man and machine-machine in the value chain in real time is a modern production system [4].

Some basic guidelines and tools for implementing 4IR in Bulgaria [8]

- Nano and biotechnology based on own resources;
- New information technology;
- Intelligent Mechanical Engineering - end products such as robot production, home robots etc.;
- Smart agriculture;
- Humanitarian technologies etc.;

References

[1]. Boer E., Leurent H., Widmer A., 'Lighthouse' manufacturers lead the way—can the rest of the world keep up?, 2019;

[2]. Frey C. B., Osborne M. A. The future of employment: How susceptible are jobs to computerasation? September 17, 2013;

[3]. Panayotova T., The Role of Concurrent Engineering in Development and Digitalization of Industrial Activities, "Innovations in discrete productions", Year VI, Issue 1 / 2018, ISSN (Print) 1314-8907, ISSN (Web) 2534-8469,

a. https://stumejournals.com/journals/innovations/2018/1/pdf, (p12-14);

[4]. Panayotova T., Development of a formal model for the implementation of business network Re-engineering, "Innovations", Year VII, ISSUE 1/2019, Sofia, ISSN print 2603-3763, ISSN Web 2603-3771, https://stumejournals.com/journals/innovations/2019/1/pdf, (p 31-35);

[5]. Salvendy G., Handbook of Industrial Engineering - Technology and Operations Management, ISBN 0471-33057-4, 3 Edition, 2001;

[6]. Schwab Klaus, The Global Competitiveness Report published by the World Economic Forum 2016;

[7]. Schwab Klaus, The Global Competitiveness Report published by the World Economic Forum 2018;

[8]. Стефанов Н., „Четвъртата Индустриална революция"/4ИР/ и България –2018 - https://pogled.info/avtorski/Nako-Stefanov/chetvartata-industrialna-revolyutsiya-4ir-i-balgariya.93970

[9]. https://www.weforum.org/agenda/2018/10/10-things-you-and-your-government-should-know-about-competitiveness-in-the-fourth-industrial-revolution/

[10]. https://intelligence.weforum.org/topics/a1Gb0000000pTDkEAM?tab=publications

[11]. https://asq.org/quality-resources/innovation

[12]. https://www.eaq.ee/quality2013/sites/www.quality2013.eu/files/webform/full-papers/Tallinn-Helsinki%20EOQ2013.pdf

[13]. https://www.ipcc.ch/sr15/chapter/chapter-5/

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OPPORTUNITIES FOR RESEARCH THE IMPACT OF INTELLECTUAL CAPITAL ON CREATING VALUE IN INDUSTRIAL ENTERPRISES

Tanya Panayotova

Abstract: In contemporary realities the value of business emerges as a main criterion for valuation of effectiveness of each economic activity. The perspective of intellectual capital enables the re-evaluation and the effective utilization of the hidden resources of the company increasing its value. A review of the definition of intellectual capital and the methods for its assesment have been made. The choice of VAIC TM - Value added intellectual coefficient with its co-use with Tobin's Q ratio for evaluation of the company's intellectual capital is justified. Based on the information collected and analyzed, a formal model for measuring the IC and its impact on the value of the enterprise is proposed.
Keywords: Intellectual capital, management, model, value, VAIC ™**,** Tobin's Q ratio

1. Introduction

In modern conditions, business is facing new and greater challenges associated with the growing globalization and the development of scientific and technological progress. Organizations must constantly change their business processes and procedures to respond adequately to the requirements, expectations and needs of customers and competitors [1]. In a world of constent changes, a need for new instruments exists which to evaluate business performance efficiency, which give to the investors and managers a clear idea of the real potential of the company in its strategic context of development.

The models of development in modern economic conditions show that in order to achieve prosperity and competitive advantage, companies increasingly rely on the creation and use of intellectual resources. The traditional economy, associated with the material production of equipment and consumer products, is increasingly giving way to development, economic exploitation and transfer of intellectual products. This tesys is also supported by the the information from sources for creation of value in the developed economies, in which they are shifted from tangible to intangible assets. The size of the intangible assets, used in the enterprises is growing constantly as in recent years 87 % of the value of the public companies forming the S&P index is due to the intangible assets. This conclusion should be reviewed in dynamics, as in 1985 the share of the intangible assets in the marked value of the companies was only 32 %, which means, that in 30 years the market has increased the role and importance of the intangible assets almost 3 times. [6].

Studies show that Bulgarian industrial enterpises have many problems, but also great unused potential for increase of their competitiveness [2]. The existence of significant difference between the market and accounting value of the enterprise is a proof for the existence of unrecognized non-material resourses, which are created internally. This potential may be realized through building a system of consistent activities for improving the opportunities for extracting value from the intellectual property, intellectual assets and human capital.

The purpose of this publication is to examine the impact of the intellectual capital on the creation of value in the industrial enterprises and on this ground to propose a model for analysis and assesment.

2. Summarized staging
Intelecual capital as expression of the non-mateiral advantages of the business

The methodology of the current study is subordinated to the aim set. On this basis, a review of the definition of intellectual capital (IC) as expression of the non-material advantages of the business has been made.

For the first time the term "intellectual capital" was used in 1968 by John Hallbraith in context of "intelecual activity". In the scientific literature the term was justified in 1991 by Steward, according to whom, the intelecual capital represents "capital asset, comprising of an intellectual material". To be consireded as intellectual capital, the knowledge must be asset, capable to be used for creation of wealth [11]. A few years later Edvinsson (1977) associated IC with "possessing of knowledge, practical experience, technology of work, customer relation and professionall skills, which give competitive advantage on the market" [3]. The term has been examined by many other authors such as Mouritsen (1998, 2000), Lynn (1988, 2000), Bukh, Larsen and Mouritsen (2001), Guthrie, Yongvanich (2004), Bulyga (2005), Chan (2009) and other. Modern business process concepts impose for an increasingly widespread presentation of intellectual capital (IC) as an integrated indicator for the value of all kinds intellectual assets of the companies.

It is difficult to identify accurately and define the essence of IC. From the examined literature sources, it appears that different variations in definitions exist. In general, it can be accepted that it is complex, dynamically changing component of generaion of an economic value and it's character is intangible. There are three basic elements in the structure of the IC - human capital, structural capital and relationship capital. In order to generate value added of the company, it is important that the essential elements of the IC to be in continuous interaction. It follows that the creation of wealth for the organization is based on a chain of transfers, i.e. individual knowledge and skills (human capital) in organizational knowledge and practices (structural capital), which subsequently affects the client capital through provision of new products and services.

The emergence of a concept of the IC is seen as a development of a concept for development of the intangible assets, for which a greater clarity as a way of reporting exists. The issues related to intangible assets are normatively definied in the International Accouting Standarts ("**IAS**") - 38 Intangible Assets. One of the major problems associated with the accounting and measuring of the IC is the fact that its core elements are difficult to formalize and measure. This is also the perceived difference between IC and intangible assets, namely only the elements of the IC that are measurable and have found a place in the company's balance sheet as intangible assets. In this way a sources that form the core value for companies remain unaccounted, for which in line with the maxim "you can only manage what you know," has a negative impact on the processes of developing strategies and decision-making on the management of enterprises by the managers [5].

3. Choise of approach for evaluation of intellectual capital

The various conditions (internal and external) of existence and realization of the activity of organizations from different areas of the economy, the views on the determining parameters of the value of the IC, the pursuit of their full identification and coverage in the analysis and the assessment lead various companies and researchers to develop multiple methods for assessing IC. At present, the most comprehensive classification and systematization of the most significant methods used to estimate the value of ICs is made by (Sveiby), who, as a result of years of observations and studies, identifies and describes 44 of them, performs their grouping by common features, dividing them into four groups: [5]

- **Direct Intellectual Capital Methods** (D1C) - The components of the IC for each organization may be different. They are individually identified and measured by a system of indicators, after which the full value is determined by summing the value of the individual

indicators;

- **Market Capitalization Methods** (MCM) - the difference between the market capitalization and the calculated share capital of the company is the IC. It is calculated on the basis of the full value of the intangible assets in financial terms, the measurement of IC is overall, most often by calculating the difference between the market value and the carrying amount of the company.
- **Return on Assets Methods** (ROA) - methods by which the growth of intangible assets and annual financial results are compared with industry averages. The value of the excess over the industry average for a given industry is used to calculate the IC value.
- **Scorecard Methods** (SC) - the various components of the IC are identified and their value is determined on the basis of score cards or graphs. This group of methods is the only one that does not use financial terms when evaluating the IC. The value of individual intangible assets is determined by various indicators, which are presented individually in tables and graphs. Depending on the goals set and the required management information, a summary assessment can be made.

However [10], these methods do not characterize the value added generated by intellectual capital. As Kasarova (2013) points out, the best idea of the effectiveness of IC is given by the VAIC™ model - Value added intellectual coefficient, which takes into account the effectiveness of tangible and intangible assets through the value they generate when being used together [4].

3.1. Model VAIC ™ - *Value added intellectual coefficient*

VAIC ™ is a trademark of Intellectual Capital Center and provides a single base for comparison between companies in different economies and economic sectors and uses information from financial statements. VAIC demonstrates the intellectual capacity of the company and its overall efficiency. The higher its value, the higher the potential of the company is and its ability to create added value, which is, in fact, a new way of understanding organizational performance [4].

The basic idea of the indicator is that the the successful crealation of value is related to the efficient use of IC and the capital employed (CE).

Or:

$$VAIC = ICE + CEE \quad (1)$$

Whereas:

ICE - Intellectual Capital Efficiency

CEE- Capital Employed Efficiency

1) Intellectual Capital Efficiency

VAIC views ICE as the sum of its components: Human Capital Efficiency and StructuralCapital Efficiency:

$$ICE = HCE + SCE \quad (2)$$

where:

HCE - Human Capital Efficiency

SCE - StructuralCapital Efficiency

▪ Human capital is a key resource for generating value added in the company and is treated as an investment rather than an expense. Human capital efficiency (HCE) is calculated as the ratio between value added (VA) and human capital (HC):

$$HCE = \frac{VA}{HC} \quad (3)$$

With an HCE value below 1, it can be concluded that the company does not create enough value added with which to cover its obligations to its employees. Optimal HCE levels take values

above 2.5 and indicate highly efficient organisation. They are usually observed in high-tech industries.

Value added (VA) is formed by the amount of profit before interest and taxes (EBIT), depreciation of tangible and intangible assets (DA) and human capital (HC):

$$VA = EBIT + DA + HC \tag{4}$$

▪ The second component of intellectual capital - Structural Capital Potential (SCE), is calculated as a ratio between Structural Capital (SC) and Value Added (VA):

$$SCE = \frac{SC}{VA} \tag{5}$$

Structural capital (SC) represents the difference between value added (VA) in a company and human capital (HC), measured by the cost of salaries and social security of the company.

$$SC = VA - HC \tag{6}$$

The structural capital (SC) is depending on the created value added and in inverse proportion with the human capital. In other words, the greater the share of human capital (HC) in value added (VA) is, the smaller the share of structural capital (SC) is. It is logical that the potential of human (HC) and structural (SC) capital should increase with the increase in overall efficiency of intellectual capital.

According to Pulic [8], the effectiveness of intellectual capital refers to the work of knowledge-carrying employees and embodying it in created products and services.

2) Invested Capital Efficiency (CEE)

In order to obtain complete information on the efficient use of the company's resources, the potential of invested (deposited) capital (CEE) must also be taken into account. Its role cannot be neglected, as the intellectual capital operates jointly with physical and financial capital:

$$CEE = \frac{VA}{CE} \tag{7}$$

3) Overall indicator for overall efficiency

In order to provide a single overall indicator for overall efficeny in creation of value added, the three performance indicators need to be collected:

$$VAIC = HCE + SCE + CEE = ICE + CEE \tag{8}$$

The VAIC ratio can be viewed as a first step in the process of defining the intellectual involvement in value creation within a company.

According to the author of this publication, defining the situation in an enterprise in terms of its intellectual capacity and its overall efficiency, requires tracing the amendmend in ΔVAIC between two comparable periods. Based on the results obtained, an analysis and evaluation of the degree of the value creation process and the degree necessary for the enterprise are made.

The VAIC meter has rather diagnostic nature, which requires its use with other systems and models for assessing the company's intellectual capital.

This study proposes that the potential use of VAIC^{TM} to be related with its jointly use with Tobin's Q ratio.

3.2. Tobin's Q ratio) – (q)

It is a method of measuring the value of a company’s IC, which can be classified to Market Capitalization Methods (MCM). The ratio is the proportion between the market value of the

company's shares to their book value or the market value of the company to the book value of the company [12].

The indicator reflects all components of the value which are not reflected in the financial statements. In addition to such diverse factors as predictable future earnings, broker concerns, expert opinions and market failures, it indirectly reflects and the intangible assets, most commonly referred to as "intellectual capital".

If q>1, this means that the market value is higher then the balance value, which results to the effect of a factor unaccounted by the traditional accounting practice and this difference is mainly due to the value of the company's IC. This is a sign for the investors to invest in the company because the assets (shares) are worth more than what was paid for them. On the contrary, if q <1, the book value of the assets is higher than the market, therefore, no funds should be invested in them and the company should release itself from the assets that lead to this decrease.

4. Formal model for assessing the impact of the intellectual capital

In this study, the author proposes a formal model for measuring the IC and its impact on the value in the enterprise, which contains several steps:

Stage One: Defining the situation of the enterprise.

As a first step of the algorithm, it is necessary to calculate the IC‘s value by joitnyl using VAICTM with the Tobin Ratio (q).

Second stage: Analysis and assessment of the situation.

At this stage, the change in ΔVAIC and Δ q between two comparable periods is calculated, as a result of which the achieved level of the process for creation of value is determined and the required level is formulated.

Third stage: Creation of IC navitagor *(Intellectual capital navigator - ICN).*

ICN is a digital and visual representation of managers' perceptions of the ability of different opportunities to create value for the organization. Thereby, they can follow the interrelations between the elements, their relative importance to the company, the ways of transfusion (transition) from one kind to another [5]. The successful introduction of the ICN creation process has been used with some refinement and adaptation of the model proposed by Roos, Pike, and Fernstrom (2005) [9]. The choice is mainly justified by the fact that the model best represents the essence of the process and, in the author's opinion it corresponds to the greatest extent to the specifics of the creation of value.

The essence of the modified ICN model creation is represented in several basic steps:

- Identifying the sources of value for the organization and deploying them in a form of a resource distinction tree (RDT). Each organization's resources portfolio can be divided into five categories. Traditional economic resources are divided into two categories - monetary and physical, while IC-related resources are divided into three categories - resources from external (mostly client) relationships (ER), organizational resources (OR) and human resources (HR). Behind this division, the main characteristic lies on the differences in the approach and the way they are managed and operated. RDT is shown in Fig 1.

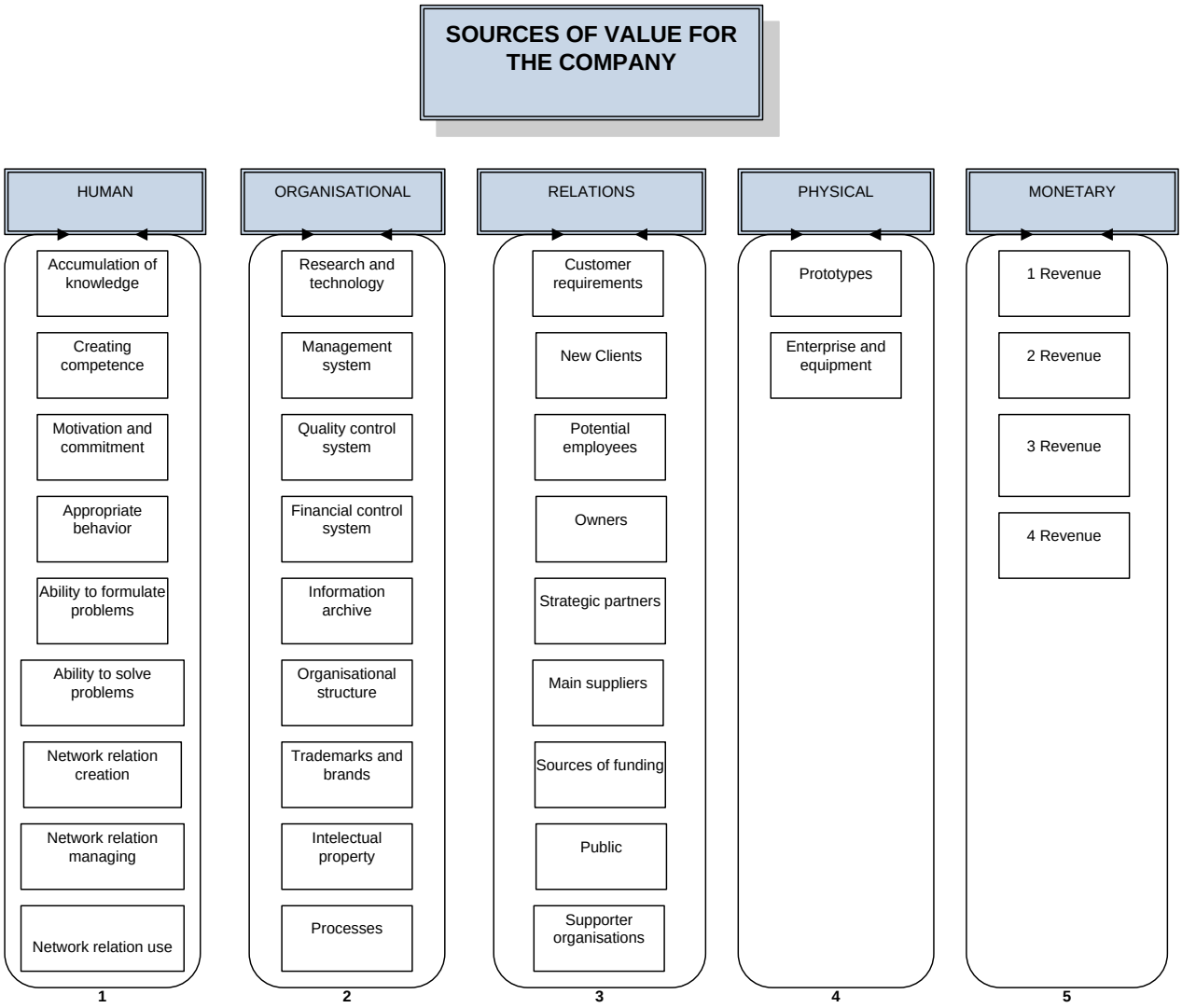

Fig. 1. Sources of value for the company

▪ Specifying the sources of value for the organization. Following of this procedure requires passing from sumarised approach of the assesemnt of the activities and processes in the organization to looking at the details, in their fundamental sources of value.

▪ Determining the relative importance (weights) of sources of value. The sources of value have different importance for maximizing the benefits of the enterprise. Therefore, they should have different weight at the assessment of the impact of IC in the creation of value.

▪ Determining the level, to which the sources meet the requirements and the contribution of IC in the creation of value.

Fourt stage: *Drafting summarized assessment and management decision.*

The summarized assesement of the level, in which the sources of value meet the requirements for maximizing the benefits of the enterprise, are determined by taking into account the reporting of the common assesments of the degree of satisfaction of the individual sources and the relative importance of those sources.

Stage Five: *Implementation of a system for realization and control*

5. Algorithm of the model

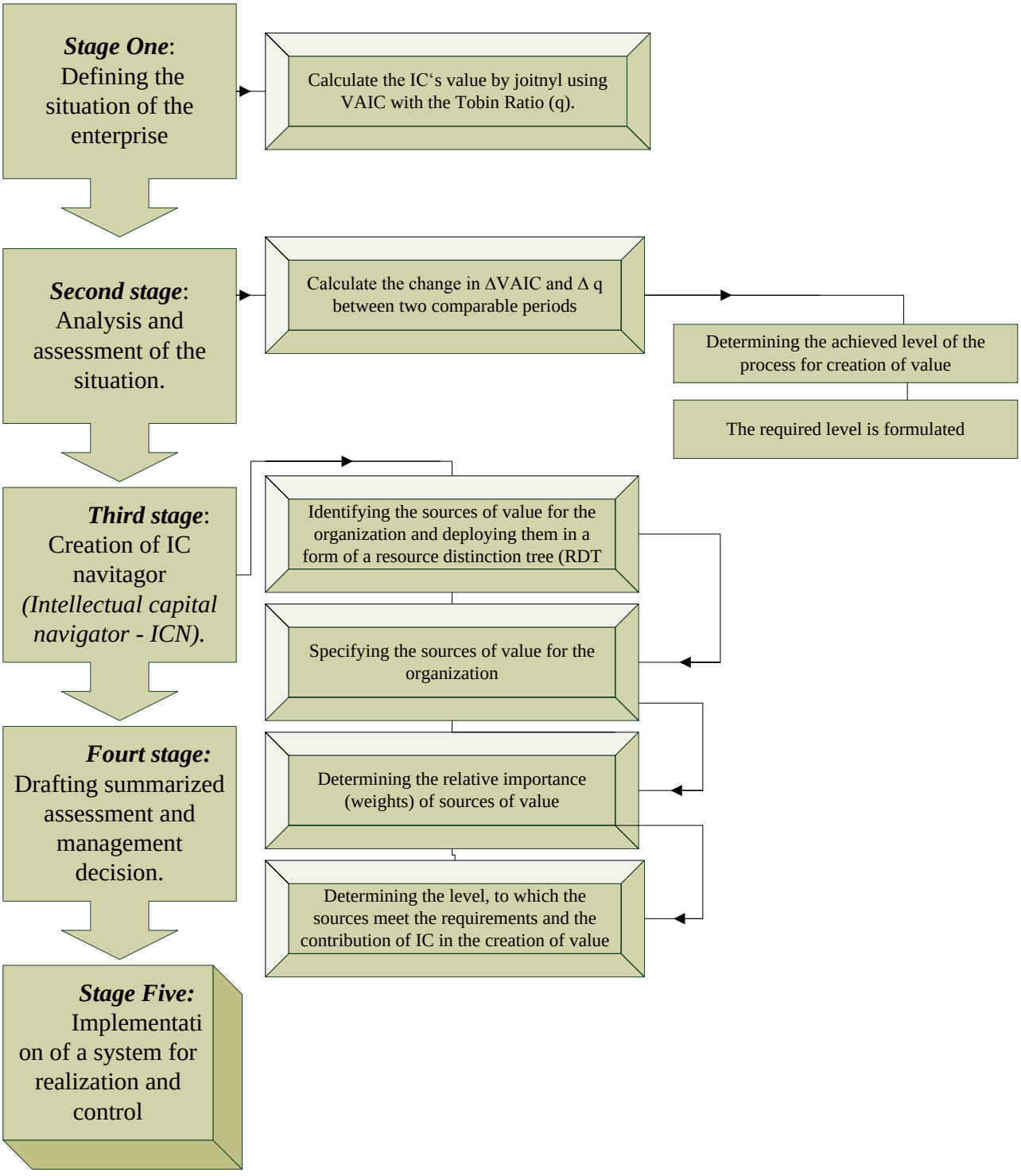

Fig. 2. Algorithm of the model

Conclusion

A need for new tools for evaluating the efficiency of business operations exists, which gives not enough clear view to the investors and managers about the real potential of the company in the strategic context of its development.

Studies show that industrial enterprises in Bulgaria have great unused potential to increase their competitiveness. . This potential may be realized by building a system of consistent activities for improving the opportunities by extracting value from the intellectual property, intellectual assets and human capital. In support of this thesis are the results from a survey among enterprises from different sectors in the country [7]. The main questions in the survey have included information for indicating the portfolio of resources from:

- external relations (mostly client);
- organizational resources (research on technology, organizational structure, processes, patents issued for inventions, certificates of registered utility patents, registered trademarks, registered industrial designs, other intellectual property);
- human resources (competence, attitudes, intellectual qualities).

The analysis of the results of the survey outlines several summaries [7]:

- The management of activities, associated with the intellectual capital is a complex and contradictory task for companies; it is difficult to systematize the available information in an orderly perspective.
- Only the elements of intellectual capital that are measurable and took place in the company's balance sheet are classified as intangible assets;
- Much of the intellectual capital's value is brought indirect to the company. It cannot be directly associated with the realization of the corporate value. Therefore, the relationship between them is often difficult to be identified and even more difficult to quantified;
- The contribution of intellectual capital to the company is expressed in revenues from products and services, R&D protection against infringement of foreign intellectual property rights, protection of intellectual property rights.

On the basis of these summaries, it can be concluded that IC, as an expression of the non-material advantages of the business, is not enough known in practice. The value which is generated as a result of an IC can only be maximized if its basic elements are known and the economic processes are managed systematically and deliberately. This entails adopting of a new management approach that goes beyond the limitations of traditionally applied management approaches and continually monitors the factors that influence the recognition of intellectual capital and the need to implement good management practices.

This publication proposes a formal model for measuring of the IC and its impact on the enterprise value. The assessment of the impact of the intellectual capital gives opportunity to rethink the hidden resources, which help to turn the value into profit.

References:

[1]. Dimitrova, K. Innovative Information and Communication Technologies - a Precondition for a Higher Competitiveness of the Organization Proceedings of the 1st International Conference "Applied Computer Technologies", ISBN 608-66225-0-3, University of Information Science and Technology "St. Paul the Apostle" – Ohrid, Macedonia, 2018.

[2]. Dimitrova, K. Modeling, measurement and management of business processes in organization Advances in Intelligent Systems and Computing, Print ISBN 978-3-319-68323-2, Online ISBN, 978-3-319-68324-9. DOI: 10.1007/978-3-319-68324-9_45EID: 2-s2.0-85031286968 Springer, Cham България, 2018, pp 410-419.

[3]. Edvinsson, L., Malone, M. Intellectual Capital: Realizing your Company's True Value by Finding Its Hidden Brainpower. Harper Business. New York. 1997.

[4]. Kasarova, V. The New Metrics of Corporate Financial Success. Evdemonia Production LtD, Sofia, 2013.
[5]. Mitev, N., Methods for evaluation of intellectual assets of the organization. Softrade, Sofia, ISBN 978-954-334-144-3, 2013.
[6]. Ocean Tomo LLC, http://www.oceantomo.com/blog/2015/03-05-ocean-tomo-2015-intangible-asset-market-value/, 2015.
[7]. Panayotova and team, Opportunities For Management of Intellectual Capital at Industrial Enterprises in North-Eastern Region, Annual Journal of Technical University of Varna., Vol. 2, http://www2.tu-varna.bg/tu-varna/index.php/izdatelska-deinost/2018-02-12-08-19-09/2018-02-12-07-47-48, 2016, pp 43-45.
[8]. Pulic, A., Intellectual capital – does it create or destroy value?. Journal of Business Performance Management, vol.8, No.1, 2004.
[9]. Roos G., Pike S. and Fernstrum L. Managing Intellectual Capital in Practice. Butterworth-Heinemann, Elsever Inc, 2005.
[10]. Sveiby, K., The New Organizational Wealth: Managing and Measuring Knowledge- Based Assets. San Fransisco: Berrett-Koehler Publishers Inc, 1997.
[11]. Stewart, T. Intellectual capital. The new wealth of organizations. New York. Doubleday/ Currency. 1997.
[12]. Tobin, J., A General Equilibrium Approach To Monetary Theory, Journal of Money, Credit and Banking, Vol. 1, No. 1, Available from: http://www.jstor.org/stable/1991374), 1969, pp. 15-29.

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MODEL OF ADAPTIVE CONTROL OF DISTRIBUTED PARAMETERS THERMAL SYSTEMS

Dian B. Dzhibarov

Abstract: Discreet models are developed for describing a class of thermal systems with partial differential equation. Different algorithms have been studied for parameter identification: method of least square error /MLQ/; extended method of least square error /EMLQ/; method of iterative quadratic maximum likelihood /IQML/ and various algorithms for evaluating controller parameters: controller with dead motion /CDM/; controller with minimal deflection /CMD/. Control problems for distributed parameters systems, described by parabolic PDEs plate type have been investigated.
Keywords: Partial differential equation (PDE), distributed parameter systems, heat transfer, adaptive control design

1. Introduction

The design of adaptive control for thermal dynamic systems, described with distributed parameters have been studied in the recent years. Different processes like diffusion, convection, heat transfer are part of a huge diversity of applications in engineering and science researching. The book [4] introduces a methodology for adaptive control of parabolic PDEs with unknown parameters such as reactors, convection-diffusion systems in chemical, thermal, aerospace and energy systems. Some approaches to discretization of models with distributed parameters are investigated to eliminate or reduce initial and boundary value problem , [3] proposed method of integrodifferential relations MIDR for optimal control design heat transfer, [5] use variation of principle of the MIDR applied in the PDE systems, [2] explore thermal systems, controlled from the boundary and contain unknown parameters that affect entire area.

2. Setting the task

One case of systems modeled with private differential equations is heat control in the plate with length L, with coefficient of thermal conductivity a. Thermal objects with distributed parameters are describe by parabolic differential equation type:

$$\frac{d\theta(x,t)}{dt} = a\frac{d^2\theta(x,t)}{dx^2} + f(x,t) \tag{1}$$

Where:
a is the coefficient of thermal conductivity,
θ - the function, describes the distribution of temperature,
x - space variable,
t - time and
$f(x, t)$ - function of the disturbing impacts. The problem is solved in the presence of inhomogeneous and homogeneous boundary conditions of the type:

$$\theta(x,0) = \theta_0(x) = \theta_0 \tag{2}$$

$$\theta(0,t) = \theta(L,t) = u(t) = u \tag{3}$$

as equation (2) is expresses the initial temperature distribution; equations (3) is the first-order boundary conditions and u is the control impact, control is from side of the boundary . We look such distribution $\theta(x,t)$ for closed area

$$D \equiv \{\theta \le x \le L; 0 \le t \le Tmax\} \quad (4)$$

of changing the variables to satisfy the initial and boundary conditions.

Given function $\boldsymbol{\theta(x,t)}$ will be solution, if she is continuous in the area $\boldsymbol{D}$ and have continuous derivatives, satisfied initial equation (1). The goal of control is achievement to approximately an even distribution of optimal control quantity (the temperature) in different points of system, moreover for minimal time.

3. Results

The heating for the plate is modeled by the finite element method programmed in C++ . The received results are only available for the horizontally aligned concrete slab. An example of a simulation performed for concrete slab is described below in the table. The influence of the variability of the heat transfer coefficient along the body is investigated. Other materials will be the subject of the future research in the area.

Combinations of algorithms for parameter identification are investigated:

- method of least square error /MLQ/;
- extended method of of least square error /EMLQ/;
- method of iterative quadratic maximum likelihood /IQML/;

and algorithms for calculating controller parameters.

- controller with dead motion /CDM/;
- controller with minimal deflection /CMD/;

Initial data for given research are:

- control impact $u = 60\,°C$;
- length of the plate $L = 1; 1.5; 2\ m$;
- value of the coefficient of heat conductivity $a = 0.027; 0.054;$
- values of spatial variable $x = 0.25; 0.5$;1
- zero initial conditions;
- forget factor $l = 1$;
- weight factor $r = 1$;

Table 1. Set values for different combinations of the methods

		MLQ		EMLQ		IQML	
		a=0.027	a=0.054	a=0.027	a=0.054	a=0.027	a=0.054
CDM	x=0.25	56.69	59.32	53.77	62.35	-	-
	x=0.50	62.66	60.00	60.82	59.99	-	-
	x=1.0	61.60	60.09	62.71	59.89	-	-
CMD	x=0.25	36.53	40.52	39.88	46.89	67.50	51.75
	x=0.50	39.47	36.02	50.65	59.70	52.00	48.10
	x=1.0	41.56	34.11	54.45	59.91	48.21	46.35

4. Conclusions

One of the goals on the topic is to consider the behavior of the distributed parameters system with random noise in the area {-2, 2} and no noise and combination of heat conductivity coefficient and spatial variables. The results show that the obtained temperature can differ by several degrees when the body is heated. This demonstrates that the variability of the heat transfer coefficient along the surface of the body should be taken into account when considering a problem of heat transfer in materials with low conductivity. The designed model and the developed approach can be used when modeling the heat transfer for more control laws in the future.

References:

[1] Велев К. , Адаптивни системи, Темпус, София, 1995

[2] Джибаров Д., Адаптивно управление на топлинни обекти с разпределени параметри, Journal of the Technical University at Plovdiv "Fundamental Sciences and Applications", Vol. 13, 2006 Anniversary Scientific Conference' 2006

[3] Asherman H., Kostin G., Saurin V., Approaches to control design and optimization in heat transfer problems – Journal of Computer and Systems Sciences International, 2010, pp. 380-391

[4] Krstic M.& Smyshlyaev A., Adaptive control of parabolic PDEs: Princeton University press, 2010.

[5] Rauh A., Asherman H, Saurin V, Kostin G., Verification and experimental validation of flatness based control for distributed heating systems, International review of mechanical engineering, 2010, pp. 188-200

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IDENTIFICATION OF NONLINEAR SYSTEMS USING HAAR WAVELET FUNCTIONS

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Abstract: Wavelet functions are aveable for describing functions, including nonlinear functions, due to their interesting properties. Haar wavelets are a set of complete orthogonal basis. The attention is directed to them, therefore thay are easy to use and computations. Application of Haar wavelet functions method for identification of nonlinear dynamic systems is described in the paper. Both the effect of noise and sampling period on the accuracy of the obtained parameter estimates is evaluated.
Keywords: Haar wavelet functions, nonlinear model, parameter identification, second order mathematical model

1. Introduction

The wavelet functions are applied successfully to approximation of functions [1]-[6], signal processing [7]-[12], fault detection [13], identification [14]-[15], etc.

Due to their properties of finite support and self - similarity, they are suited to depict functions with local nonlinearities and fast variations. For signals represented as functions of time, the wavelet functions provide efficient localization in both time and frequency or scale.

A family of wavelets can be constructed from a function $\psi(t) \epsilon L_2(R)$. It denote the vector space of measurable functions that are absolutely and square integrable:

$$\int_{-\infty}^{\infty} |\psi(t)|\, dt \quad < \infty \tag{1}$$

$$\int_{-\infty}^{\infty} |\psi(t)|^2\, dt \quad < \infty \tag{2}$$

Sometimes ψ(t) is known as a "mother wavelet" which is confined in a finite interval. "Daughter wavelets" $\psi_{a,b}(t)$ are then formed by translation ***b*** and contraction ***a***.

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right), a, b \in R, a \neq 0 \tag{3}$$

where ***a*** is positive and defines the scale and ***b*** is any real number and defines the shift. The pair ***(a, b)*** defines a point in the right half plane $\boldsymbol{R}_+ \times \boldsymbol{R}$.

The Haar wavelets, proposed in 1909 by Alfred Haar, are the simplest type of wavelets. The obtaining of this kind of wavelets is done by a basic (mother) wavelet function ψ(t) and a scaling function φ(t), which are determined by the following formulas:

$$\psi(t) = \begin{cases} 1, & 0 \leq t < 1/2 \\ -1, & 1/2 \leq t < 1 \\ 0, & otherwise \end{cases} \tag{4}$$

$$\phi(t) = \begin{cases} 0, & 0 \leq t < 1 \\ 1, & otherwise \end{cases} \tag{5}$$

The orthogonal set of Haar functions (Fig.1) is a group of square waves with magnitude of ± 1 in some intervals and zeros elsewhere. Just these zeros make the Haar transform faster than other square functions such as Walsh's.

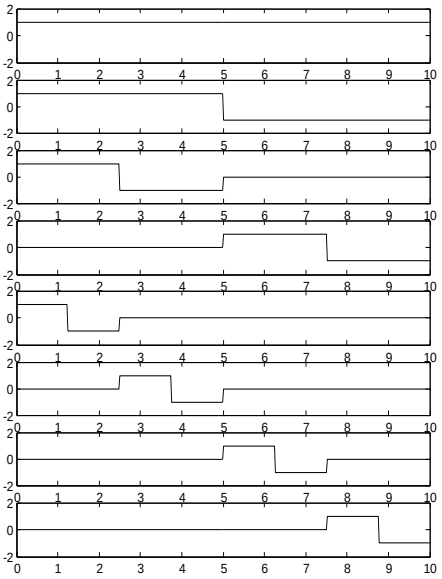

Fig. 1. Orthogonal set of Haar functions

In discrete form, Haar wavelets are related to a mathematical operation called the Haar transform. The Haar transform can be used for removing noise.

Haar wavelets are used to expand all signals, since thay can form a complete orthogonal basis for the appropriate function space. In doing so, the differential equations can be transformed into a system of algebric equations in unknown parameters or into matrix equations. Using the least squares method, the unknown system parameters are estimated.

In the paper the Haar wavelet method is applied to the identification of dynamic systems, described by second order nonlinear mathematical models. Several good properties of Haar wavelets are used in the algorithm. The identified model is validated by comparing the simulated output signal with that of the obtained mathematical model. The summary relative parameter errors and relative output errors are also used for comparison.

2. Application of Haar wavelet functions in defining the mathematical model parameters

Let it be assumed that the mathematical model is of the type

$$\hat{a}_4.y''(t).y'(t) + \hat{a}_3.y''(t) + \hat{a}_2.y'(t) + \hat{a}_1.y(t) = u(t) \tag{6}$$

The estimation of the parameters of equation (6) can be done by the following basic steps.

1) Representation of the equation (6) into a matrix form

$$A.Q = U \tag{7}$$

where:

A - a matrix containing the approximating and detailing coefficients of the output of the system;

U - a matrix containing the approximating and detailing coefficients of the input of the system;

Q - a matrix containing the model parameter estimations.

2) Application the least squares method to solve the matrix equation and find the desired parameter estimates.

3) Quality assessment of the resulting model.

3. Numerical experiments

Numerical experiments with equation (6) were performed to confirm the working efficiency of the method, where the exact values of the parameters are as follows: $a_4 = 0$; $a_3 = 400$; $a_2 = 4$; $a_1 = 1$. The oscillations *y(t)* at sampling interval $\Delta t = 0.1s$ and time of observation $T_0 = 1200s$ are simulated. Using wavelet functions properties, the differential equation (6) can be represented as the following matrix equation

$$\begin{bmatrix} a_{L,1}^{IV} & a_{L,1}^{III} & a_{L,1}^{II} & a_{L,1}^{I} \\ a_{L,2}^{IV} & a_{L,2}^{III} & a_{L,2}^{II} & a_{L,2}^{I} \\ d_{L,1}^{IV} & d_{L,1}^{III} & d_{L,1}^{II} & d_{L,1}^{I} \\ d_{L,2}^{IV} & d_{L,2}^{III} & d_{L,2}^{II} & d_{L,2}^{I} \end{bmatrix} \cdot \begin{bmatrix} \hat{a}_4 \\ \hat{a}_3 \\ \hat{a}_2 \\ \hat{a}_1 \end{bmatrix} = \begin{bmatrix} A_{L,1} \\ A_{L,2} \\ D_{L,1} \\ D_{L,2} \end{bmatrix} \tag{8}$$

where:
L- decomposition level;
a_L- level approximation of the output signal;
d_L- level detail;
$\hat{a}_4$, $\hat{a}_3$, $\hat{a}_2$, $\hat{a}_1$ - parameter estimations;
A_L = level approximation of the input signal u(t).

Suitable Matlab file is proposed using the algorithm. The estimations of the parameters of the mathematical model (6), the summary relative parameter error δ and the relative output error E are obtained. The original output signal y(t) and the model output signal ym(t) are compared and are shown in Figs. 2 – 4.

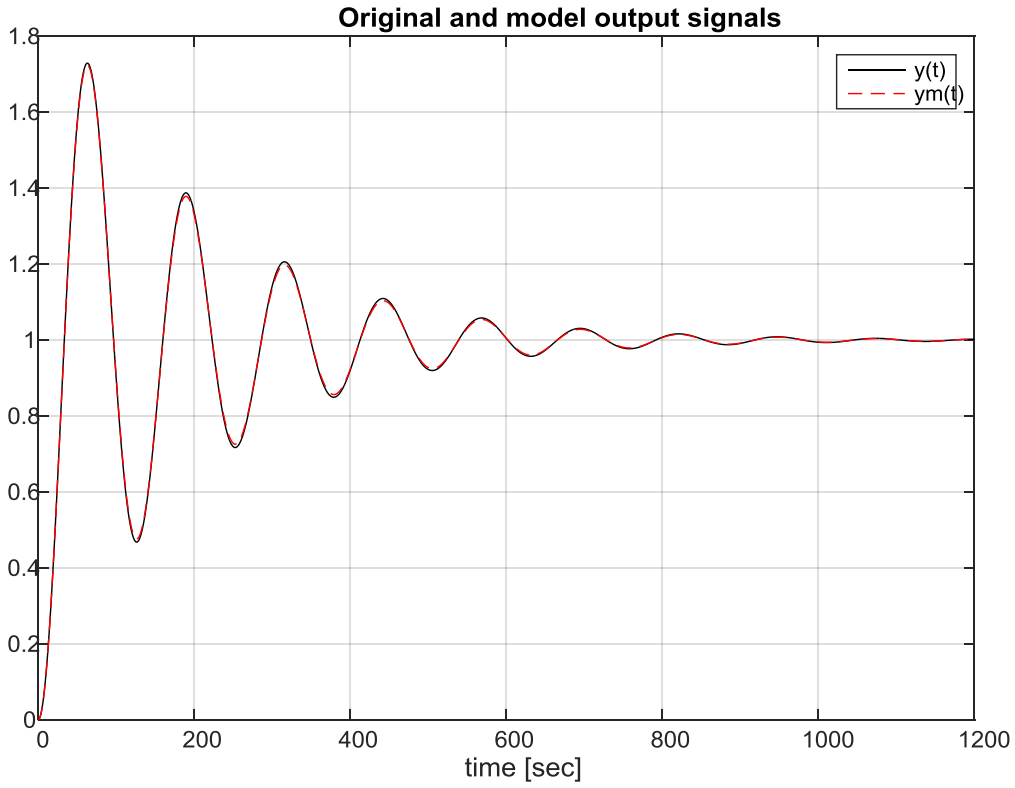

Fig. 2. The original output signal y(t) and the model output signal ym(t) ($\Delta t=0,1s$)

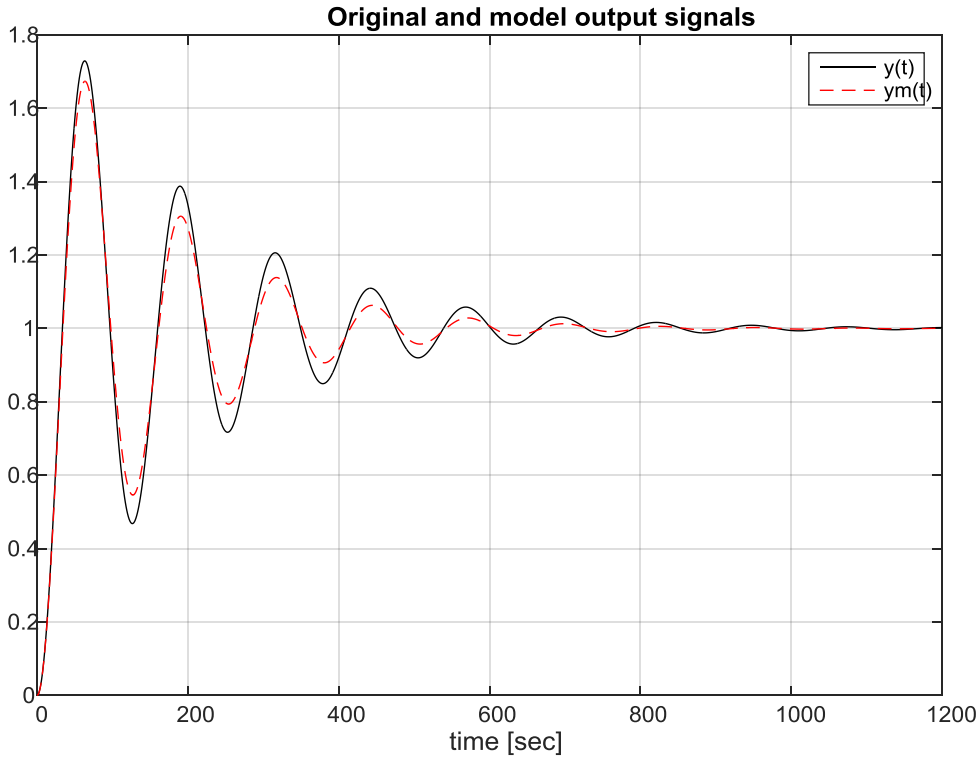

Fig. 3. The original output signal y(t) and the model output signal ym(t) ($\Delta t=1s$)

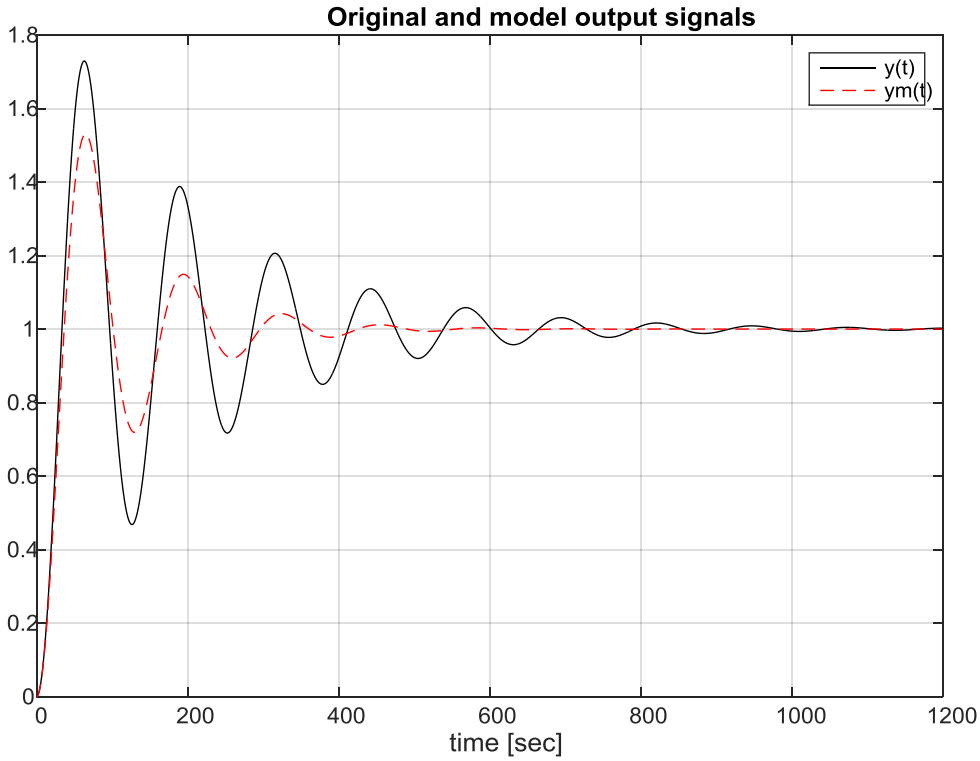

Fig. 4. The original output signal y(t) and the model output signal ym(t) ($\Delta t=4s$)

The sampling interval Δt significantly affects the values of the parameters as shown in Figs. 2 - 4 and Table 1.

Table 1. Influence of the sampling interval Δt over the accuracy of the model

Δt [s]	**0.1**	**1**	**4**
$\hat{a}_4$	0.0000	0.0000	0.0000
$\hat{a}_3$	400.2009	402.0871	409.4162
$\hat{a}_2$	4.1000	5.0008	8.0134
$\hat{a}_1$	1.0000	1.0000	1.0000
E [%]	0.0013	0.0950	0.7387
δ [%]	0.0561	0.5786	2.5588

The impact of the noise level γ over the model accuracy is shown in Fig. 5 and Table 2.

Table 2. Influence of the noise over the model accuracy

γ [%]	**0**	**0.10**	**0.25**	**0.50**
$\hat{a}_4$	0.0000	24.0602	157.9510	588.6595
$\hat{a}_3$	409.4162	407.6009	398.6547	370.0009
$\hat{a}_2$	8.0134	8.0133	8.0156	8.0246
$\hat{a}_1$	1.0000	0.9999	0.9992	0.9969
E [%]	0.7387	0.7360	0.7275	0.7930
δ [%]	2.5588	6.3870	39.4998	147.3515

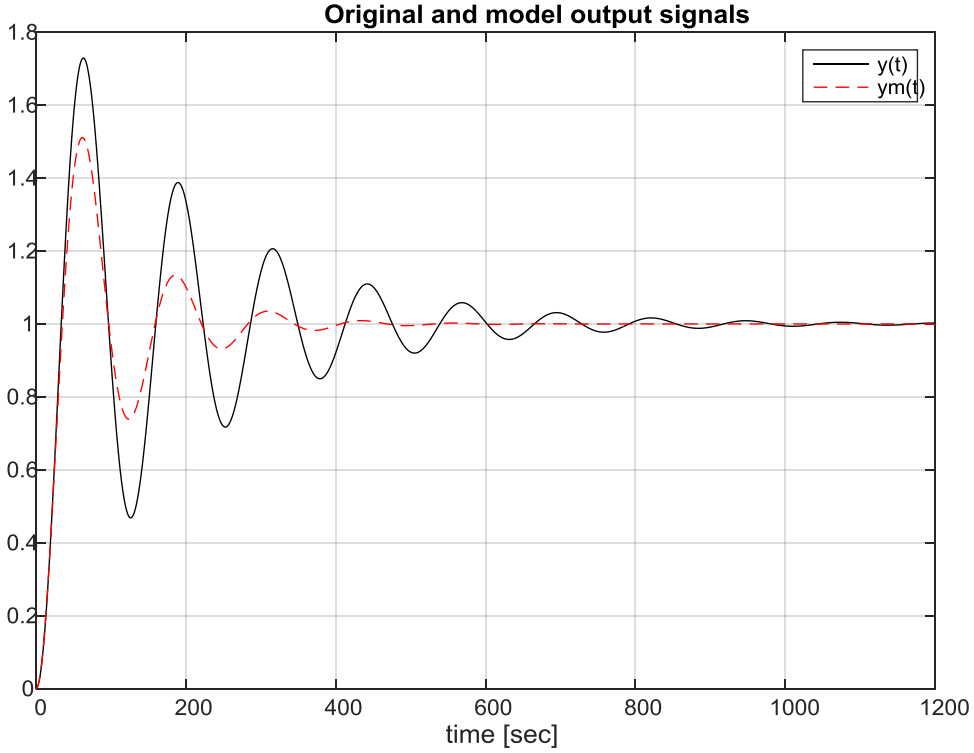

Fig. 5. The original output signal y(t) and the model output signal ym(t) ((Δ*t=4s,* γ=0,5%)

Increasing the noise level has the greatest influence on the estimation of the parameter a_4.

4. Conclusions

The paper examines the possibility of applying Haar wavelet functions in parameter identification of second order nonlinear mathematical model. The results indicate that the Haar wavelet method can reliably identify the characteristics of the second order systems. The presented studies examine the impact of the sampling interval over the accuracy of the assessment of the parameters of the model. By decreasing the sampling interval, a relative error at output E =

0.0013% is reached. Based on the obtained results using deteriorated data, it can be concluded that the noise level significantly affects the parameters with small values.

References

[1]. Cao, L., D. Chen, J. Fan, Face Recognition Using the Wavelet Approximation Coefficients and Fisher's Linear Discriminant, 5th International Congress on Image and Signal Processing (CISP 2012), 2012, pp. 1253-1256.

[2]. Riera-Guasp, M., A. Antonino, J. Roger-Folch, P. Molina, The use of the wavelet approximation signal as a tool for the Diagnosis of Rotor Bar Failures, Vienna, Austria, International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives - SDEMPED 2005, 2005.

[3]. Tam, K., S. Wong, C. Tse, Wavelet-Based Piecewise Approximation of Steady-State Waveforms for Power Electronics Circuits, IEEE International Symposium on Circuits and Systems, 2005, pp. 2490-2493.

[4]. Todorova, M., R. Parvanova, Application of wavelet functions in signal approximation, Macedonia, The 1st International Conference Applied Computer Technologies (ACT 2018), 2018, pp. 86 – 89.

[5]. Vetterli, M., Wavelets, Approximation, and Compression, IEEE Signal Processing Magazine, 2001, pp. 59-73.

[6]. Yang, J., S. Fu, L. Yuan, H. Ma. Iterative Learning Control Using Wavelet Approximation for Permanent Magnet Linear Synchronous Motor, Seoul, Korea, Proceeding of International Conference on Electrical Machines and Systems, 2007, pp. 614-618.

[7]. Damlamian, A., S. Jaffard, Wavelet Methods in Mathematical Analysis and Engineering, France, Universite Paris XII, 2010, pp.179.

[8]. Liu, J., Damage Detection via Wavelet Transform, Taiwan, Graduate Institute of Communication Engineering College of Electrical Engineering and Computer Science National Taiwan University, 2011, pp. 22.

[9]. Tang, Y., Wavelet Theory Approach to Pattern Recognition 2nd Edition, Chongqing University, China and Hong Kong Baptist University, Hong Kong, Series in Machine Perception and Artificial Intelligence - Vol. 74, 2009, pp. 463.

[10]. Todorova, M., R. Ivanova, Research and signal analysis with different classes of wavelets, Macedonia, 51st International Scientific Conference on Information, Communication and Energy Systems and Technology Systems (ICEST), 2016, pp. 157 – 160.

[11]. Vries, A., Wavelets, Germany, FH Sudwestfalen University of Applied Sciences, 2006, pp.36.

[12]. Wang, X., J. Wang, H. Dai, Y. Li, Research on Fault Signals Recognition in GIS Based on Wavelet Theory, 24th Chinese Control and Decision Conference (CCDC), 2012, pp. 1442-1445.

[13]. Chen, C. M., K. A. Loparo, Electric fault detection for vector-controlled induction motors using the discrete wavelet transform, Proceedings of the American Control Conference, 1998, pp. 3297-3301.

[14]. Du, H., S. Nair, Identification of friction at low velocities using wavelet basis function network, Proceedings of the American Control Conference, 1998, pp. 1918-1922.

[15]. Todorova, M., R. Parvanova, Application of wavelet functions for identification of ship models, International Maritime Association of the Mediterranean, 2019.

[16]. Burrus, C. S., A. Gopinath, and H. Guo, Introduction to Wavelets and Wavelet Transforms, Prentice Hall, 1998.

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POSSIBLE PROBLEMS AND FACTORS AFFECTING QoS IN TRANSMISSION OF VOICE OVER IP NETWORK

Plamena J. Edreva, Todorka N. Georgieva

Abstract: This article introduces issues and factors that affect QoS when transmitting voice data over an IP network. The factors affecting the quality of service are analyzed and the possible problems that arise when transmitting data over the VoIP network are emphasized. Guidelines are given for the practical solution of the problems that have arisen.
Keywords: VoIP, QoS, IP

1. Introduction

The basic requirement for VoIP networks is the quality of services. If VoIP telephony cannot offer quality equivalent to that of classic telephones, then the application will not make sense [1]. Delays and packet loss are not critical to much of the traffic that passes through the IP data network. Packets that arrive in the wrong order are buffered and after the delayed packets arrive, their order is restored and the missing ones are sent again. In contrast, voice data is hypersensitive to slowing down and losing packets. This leads to poor connection quality.

2. Factors affecting quality, approaches to achieving and managing QoS

2.1. Factors influencing QoS in voice transmission

Several factors can reduce the quality of audio transmitted over the network:

- reliability;
- bandwidth;
- delay;
- jitter;
- packet loss;
- security.

A major factor in the transition from traditional to IP telephony is the reliability of the future system. The standard goal is to achieve 99.999% reliability. This means no more than 5.3 minutes per year for the system not to operate. With proper planning, design, implementation and operation, this can be achieved with IP telephone networks.

Manufacturers of classic plants achieve the desired reliability by accepting the system to be inoperable only when the problem is within the system itself. The definition itself does not cover the whole process of a single call from start to finish. For a complete analysis of an IP telephone system, the elements that affect reliability must be considered and evaluated individually:

- hardware;
- software;
- transmission environment;
- power supply;
- Network design.

Hardware reliability is determined by the Telcordia method - Part Counting, which analyzes the average failure time for all the components in the conversation path between point A and point B.

In order to accurately determine the reliability of a network device, it is necessary to consider the time at which it does not work due to software problems.

The power supply affects the entire IP telephone network. Power failure does not only affect a device, it affects the entire network.

The design of the network topology and the network protocols used are important for reliability. Recovery or transfer time to a backup device may exceed 5 minutes if the network is incorrectly designed with inappropriate protocols and configurations.

One of the important things when building VoIP networks is determining the bandwidth required for quality voice communications. Insufficient bandwidth can result in packet loss and other service quality issues.

One of the benefits of VoIP is that it integrates voice and data into a single network. Voice services are more sensitive to lack of bandwidth.

Delay is the length of time a packet reaches its recipient. Delay cannot be completely avoided, but the aim is to achieve a minimum. Not always high delay leads to poor connection quality, but it may cause a lack of speaker synchronization.

Jitter is the difference between the time it takes for a package to be received and the time it is received [2]. One of the reasons for jitter is the change in queue size in network device buffers. Another reason is the ability of individual packets to cross different paths across the network. Media gateways use compression buffers to avoid the negative effect of jitter. They help to reconstruct the voice data. In these buffers, packages that have arrived earlier are waiting for an interval of time.

There are many reasons for losing packages. It cannot always be avoided. When there is network congestion, buffers on network devices may overflow. This results in rejection of newly received packages. The allowable percentage of lost packets depends on the codec used. Using G.711, losses below 5% would not cause a drop in quality. This percentage is significantly lower for highly compression codecs such as G.723.1 and G729A. They are 1% and 2%, respectively. In order to enter these boundaries, various Class of Service (CoS) methods are used that give priority to the transmission of VoIP traffic.

The rapid deployment of VoIP provides prerequisites for increasing the risk of security threats and necessitates the urgent development of a security environment. Security threats can be divided into two classes:

- Service denial threats - renders system resources unusable;
- threats to compromise personal resources - data resources become available or used by attackers [3].

The most common attack is DoS. It causes a loss of service or the network stops functioning for minutes or even days. The attack is accomplished by exhausting the system's resources or by consuming the entire bandwidth. Bandwidth consumption is an attack on network resources. A "service failure" occurs when the network connection capacity is busy and data transmission is impossible or too slow. Another threat is wiretapping. This is done by improperly intercepting Real-time Transport Protocol (RTP) packets that transmit voice data. Another possible risk is the problem of spam spreading over IP phones. An example is the time taken by a VoIP phone user to delete unwanted advertising messages. VoIP technology uses IP packets and standard security measures are not always applicable.

Using virtual LANs helps with security. The VLAN used for voice data must be separated from the rest by packet filtering mechanisms or firewalls.

Traffic carrying voice data should be encrypted whenever possible, but not all end devices have the necessary encryption resources. Then, so-called firewalls are used.

Firewalls are used to create a barrier between the local and the internal network and its connection to the outside world. There are four main features of a firewall:

- block data likely to conceal hacking attacks;

- hide network information by masking the IP address of the network with the IP address of the firewall for outbound traffic;
- keep logs of the information flow with records of specific events [4];
- Limit traffic to avoid denial of service attacks, routers and switches must be configured in a way that prohibits one type of traffic from running out of resources, such as bandwidth, memory, or processor time.

2.2 Approaches to achieving the required quality of service

There are many different suggestions for achieving and securing QoS. They can be grouped into three groups:

- Reservation of resources. Resources are assigned for the duration of a session and they are reserved for that session before it is built. Thus, there is a certain refusal of the full freedom of access to resources under the IP philosophy and a return to the practice of channel switching to choose and preserve the path between subscribers before the call begins;
- categorizing traffic. Here is a categorization of traffic flows from different telefony services into different classes. Different classes of traffic can be given different priority. Usually, traffic from isochronous services, such as speech, has a higher priority over elastic traffic, such as email. To some extent, this approach is easier to implement, but it should not be allowed for the traffic flow of a telefony service to take up the entire resource. Therefore, a method of equitable allocation of resources is needed;
- providing additional resources. The simplest way to satisfy QoS requirements is to resize the network. Not the cheapest way, but probably the most used one so far. If you need to run VoIP traffic on a data network, it is natural to add an additional resource to the network.

2.3. QoS management

QoS management helps set and evaluate QoS goals and policies. A more general description of the methodology for achieving a quality of service is as follows:

The network is measured and surveyed in order to determine the traffic characteristics, identify bottlenecks in the network. It is also good to examine the behavior of the applications to which QoS will apply. Imposing quality on network maintenance and monitoring go hand in hand. QoS cannot be achieved without sufficient network information.

QoS techniques are available when the traffic characteristics are well researched and applications selected for the purpose of improved service quality are selected.

Evaluate the results by testing the reactions of the selected applications to determine if the QoS objectives have been achieved. In an ever-evolving network environment, QoS is not a one-off solution, but is an ongoing process of design, analysis, control, configuration, an integral part of network design [5].

3. Conclusion

VoIP dramatically reduced communication costs by sharing network infrastructure between data and voice. IP telephony is increasingly replacing traditional telephone networks. One of the steps for implementing an IP telephone system is to configure the network devices for voice data transmission and the necessary mechanisms that ensure the quality of services.

4. References

[1]. D. Richard Kuhn, Tomas J. Walsh, Steffen Fries. Security Considerations for Voice over IP Systems. //National Institute of Standards and Technology, 2005, NIST SP 800-58
[2]. William C. Hardy, "VoIP Service Quality - Measuring and Evaluating Packet-Switched Voice", McGraw-Hill, 2003, ISBN 0071410767
[3]. Rainer Martin, Ulrich Heute, Christine Antweiler, Advances in Digital Speech Transmission, John Wiley & Sons, Ltd, 2008, ISBN 978-0-470-51739-0
[4]. Angela Orebaugh, "Wireshark and Ethereal Network Protocol Analyzer Toolkit", Syngress Publishing, 2007, ISBN 9780080506012
[5]. Kun I. Park , "QoS in Packet Networks", Springer, 2005, ISBN 978-0-387-23390-1

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SOFTWARE DEFINED NETWORKS – A BRIEF STUDY

Rosen S. Radkov

Abstract: Modern computer networks are complex to manage, and adapting to new business requirements and problems is very difficult. This article presents a brief study of the new computer network management technology called Software Defined Networks. In this paper are expailed motivation of their creation, their main concepts and trends of their development. Software Defined Networks separate from each other the functional layers of a computer network - data plane from control plane. This functionality enhances the programming capability, flexibility and manageability of the network.
Keywords: OpenFlow, Software-defined networking, dependability, network virtualization

1. Introduction

The management of data flows on computer networks is usually decentralized. Modern computer networks are large in size and complex in structure, which makes it difficult to manage them using this decentralized approach. To implement the desired high-level network policies, network administrators must configure many network devices individually. This is usually done using command line interface (CLI) commands that are specific to the operating systems of each manufacturer. In addition to the complexity of their configuration, computer networks need to adapt to changes in their load and be resistant to the dynamics of their faults. The task is more complex, because current networks are vertically integrated. Control plane, which decides how to handle network traffic, etc. data plane, which redirects traffic according to the decisions made by the control logic, resides in the network devices, reducing flexibility and limiting the development of the network infrastructure. In a heterogeneous network, there are virtually no mechanisms for automatically configuring it. Implementing a specific policy in such a dynamic environment is therefore a major challenge.

2. Motivation for development of Software Defined Networks

The architecture of a computer network can be represented by three planes of functionality: a management plane, a control plane and a data plane (Fig.1).

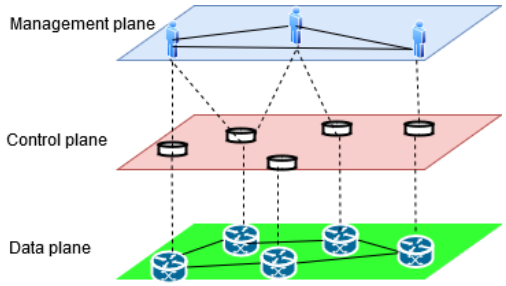

Fig. 1. Architecture of computer network

The management plane realize network management functionality and it corresponds to software services [1] , used for device configuration and monitoring of devices health status. The protocols used to populate the forwarding tables of the elements of the data plane are the essence of the control plane. The data plane include the network devices that are responsible for forwarding the data. Network policies are defined in the management plane, the control plane imposes policies and

the data plane implements them by forwarding the data. Traditional networks are highly decentralized and the control and data planes are tightly interconnected because they are embedded in the same network devices. In the beginning of the Internet this was considered as important feature as it seemed the best way to ensure the sustainability of the network, which was a the main goal of the network design. In practise this approach is more effective in terms of network performance, with rapid increases in line speed and port density.

The result is a very sophisticated and relatively static architecture [2], [3] □ which makes traditional networks very complicated to set up and manage. Often, incorrect network configurations are encountered in practice, which is a prerequisite for errors in their operation. According Feamster [4] more than 1000 configuration errors were observed in BGP routers. An incorrectly configured device can lead to unwanted network behavior (including, but not limited to, packet loss, redirection circuits, unscheduled routes, or breach of service contract). Some vendors offer customized solutions for specialized hardware, operating systems, and management programs for network management. To provide quality support for the network infrastructure, network operators must acquire and maintain a variety of management solutions and relevant specialist teams. On the other hand, the costs of acquiring and maintaining network infrastructure are considerable, with a long payout period that hinders the rapid addition of new features and services such as access control, load balancing, energy efficiency, traffic engineering. The complexity of the network is also increasing due to the presence of a number of intermediate devices that add functionalities such as IDS, IPS, DPI and more.

A number of trends have encouraged network equipment manufacturers and users to rethink traditional approaches to network architecture design. Particular attention should be paid to the following:

a) Change in the volume and patterns of network traffic

The application software systems used today are not always the classic client-server model, and in many cases send requests to multiple servers. This is a prerequisite for generating more volume. There is an enormous number of employees who require remote access to the corporate network to fulfill their work responsibilities. They access from various types of computing devices - mobile personal devices such as smartphones, tablets and laptops. This, on the one hand, helps their remote work, but at the same time contributes to a significant increase in network traffic. Also influenced by the increased number of devices in the IoT category. Most such devices generate relatively little traffic, but there are exceptions, such as CCTV cameras. The increasing number of such devices is putting a significant strain on the corporate network.

b) Increasing distribution and use of cloud services

The large-scale development of data centers has helped the development of the so-called third party services which are so called cloud services. The technologies they provide provide greater flexibility for IT solutions to deliver different types of services, as well as shorter time for deployment of IT infrastructure. However, cloud service providers need an intelligent way to manage the resources that are shared between different clients, because the traditional way impedes their development.

c) Increasing data volume - Big Data

The processing of large data sets necessitates the easy incorporation of additional capacity and better management of the serving network infrastructure into the data centers.

d) The need for an intelligent system that makes it easy to implement the policies required by businesses and easily manage the behavior of network devices.

Although modern technologies allow the transmission environment to provide more bandwidth and network devices have increasing performance, traditional network architectures are

difficult to adapt and adjust to the increasing complexity of business processes served, volatility and large load volume, quality of service (QoS) requirements.

3. The essence of Software Defined Networks

The Software Defined Networks (SDN) originate from Stanford University, where team of scientists lead by Nick McKeown developed OpenFlow [5] .The ideas embedded in the definition of SDN suggest that a network architecture be created in which the data forwarding that takes place in the data plane is controlled by a remote control plane separated from the data plane. The OpenFlow specification describes both the protocol through which the controller and switch interact, as well as the expected behavior of the switch. Exemplary architecture of the OpenFlow solution is illustrated on Figure 2.

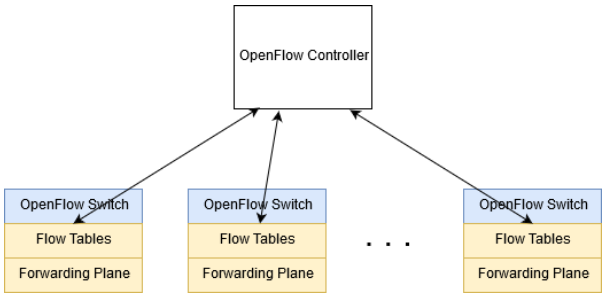

Fig. 2. Architecture of an OpenFlow solution

The operation of an OpenFlow solution can be described in a simple way in the following ways:

• Flow tables are loaded from the controller into the switches.

• Each of the switches evaluates the incoming packets, searches the tables for a matching flow, and then performs the action associated with it.

• If the switch does not find a matching flow, it forwards the packet to the controller for instructions on what action to take with it.

• Once the controller make decision, he updates the switch tables to handle them locally.

The networking industry has repeatedly changed the ideas embedded in the original view of SDN, and sometimes the SDN is considered to be any software that manages the network. So let's try to better define what is a SDN.

It can be said that the architecture of an SDN network is subject to four basic principles [6] :

1) Separation of Control plane and Data plane. Control function is removed from network devices and they are converted into packet forwarding devices.

2) The characteristics of the data flow, not the destination, are used as criteria when deciding on a forwarding. SDN, respectively OpenFlow, defines data flow as a sequence of packets between source and destination. All flow packets are handled by the same forwarding rules on network devices. This makes it possible to unify the behavior of different types of network devices: routers, switches, firewalls, and middleboxes [7] . Flow-based control allows for unprecedented flexibility, limited only to the capabilities of embedded flow tables [8] .

3) A component called the SDN controller or network operating system (NOS) is introduced into which the control logic is moved. Like the traditional operating system, NOS is a software platform that, by introducing an abstract type of network, facilitates devices programming.

4) For network programming, network applications are used which, by using the NOS functions, interact with the data plane devices. They do not need to have direct contact with network devices. This is a major feature of SDN.

Centralized network management provided by SDN offers the following additional benefits:

1) Changing network policies becomes easier and less error-prone because it is done through high-level languages.

2) The controller has information about the status of the entire network.

3) The development and deployment of new network features, services and applications is facilitated.

4) The controller can automatically respond to false changes in network status and to keep network policies intact.

All of this gives grounds to say that the implementation of SDNs can overcome the limitations of current network infrastructures. It is important to clarify that a logically centralized programming model does not mean that the system is physically centralized.

According Schenker SDN can be defined by three fundamental abstractions: forwarding, distribution, and specification [9]. Forwarding abstraction should allow network applications to manage forwarding without the need for basic hardware details. In that sense, OpenFlow is one realization of such an abstraction. It can be considered the equivalent of a "device driver" in an operating system. Centralized management allows distribution abstraction to protect SDN applications from network problems that arise from the state of distributed devices. NOS fulfils the role of the distribution which is responsible for propagate the control commands on the forwarding devices and collects status information about the forwarding layer (network devices and links), to offer a global network view to network applications. Specification abstraction should allow a network application to set the desired network behavior, relying on other layers to apply it correctly. Figure 3 shows the SDN architecture according to the proposed.

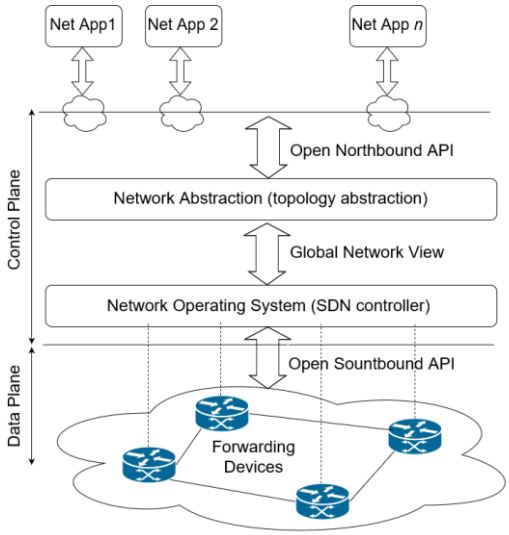

Fig. 3. Abstractions of SDN architecture

As mentioned above, in traditional networks, mixing the management and forwarding of data, which is embedded in the network elements, makes it difficult to add new functionalities and make modifications to them. The reason is that a modification must be made to the control plane of all network devices. And the introduction of new network features requires the addition of expensive and specialized equipment (also known as midrange), which is difficult to configure and usually requires a change in its topology. Such features are: load balancing, intrusion detection systems (IDS) and firewalls. A number of benefits of applying SDN can be noted:

• Easy programming of network applications due to the sharing of abstractions provided by the control platform and / or network programming languages.

• All applications share the same global topology and network status information, making for more consistent and effective policy decisions.

• There is no need to develop a location strategy for new features, as network applications can reconfigure routing devices from any part of the network.

• The integration of different applications becomes easier [29]. For example, load balancing and routing applications can be combined sequentially, with load balancing decisions having precedence over routing policies.

The composition of an SDN in detail can be defined as a set of the following components:

Forwarding Devices (FDs): These are hardware devices with no sophisticated software that perform a set of elementary operations and are part of the data plane. They work on the basis of defined sets of instructions (eg flow rules) used to take action on incoming packets (eg, forward to specific ports, accept/drop, forward to a controller and etc.). These instructions are defined by the southbound interfaces (for example, OpenFlow, ForCES and etc.) and installed on the these devices by the SDN controllers via the southbound protocols.

Data Plane (DP): It consists of interconnected routing devices that are connected to each other through network connections.

Southbound Interface (SI): It defines, through the API, the set of instructions of the forwarding devices as well as the communication protocol between the forwarding devices and the control plane elements.

Control Plane (CP): The elements of the control plane program the forwarding devices using SI. Applications and controllers form the control plane, which is why some call it the "network brain"[6].

Northbound Interface (NI): This is the interface that application developers need. For this purpose, the network operating system provides them with an API called the northbound interface. The northbound interface abstracts the low level instruction sets used by southbound interfaces to program forwarding devices.

Management Plane (MP): This plane consists of a set of applications that utilize the features offered by NI to apply network control and logic of operation. This list may include applications related to routing tasks, firewalls, load balancing, monitoring etc.. This plane defines policies that translate into southbound-specific instructions that program the behavior of forwarding devices.

4. Development forecasts

The development and implementation of SDN is accompanied by a number of requirements that can be applied to this technology. They can be summarized as follows:

1) Adaptability

Networks need to adapt and respond dynamically to application needs, business policies, and network status.

2) Automation

Policy changes should be propagated automatically to reduce manual work and errors.

3) Maintainability

This functionality is necessary to minimize downtime when make software updates, hardware upgrades or prophylactic of the components of the SDN.

4) Model management

It is needed to make network management possible at model level to avoid reconfiguring all network devices in the event of a change in network architecture or concept.

5) Mobility

Control functionality must be mobility-responsive, including mobile user devices and virtual servers.

6) Integrated security

Network security should be integrated into the applications, not as an additional solution.

7) On-demand scaling

According the Statista statistics [10] the size of the SDN market worldwide from 2013 to 2021 (Fig.4). In 2019, the global SDN market was expected to reach 9.5 billion U.S. dollars in size.

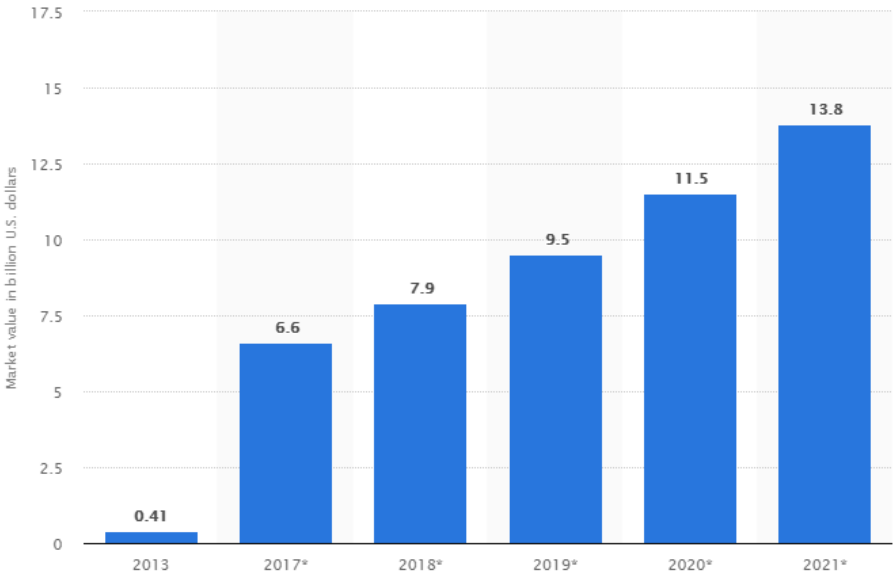

Fig. 4. SDN market size worldwide from 2013 to 2021

According to another studies [11], [12], the global market for SDN products and services in cloud organizations and providers will grow from $7.8 billion in 2015 to $35.6 billion in 2018 and $59 billion in 2023. This includes network infrastructure, SDN devices and connected with this consultancy.

For the ten years since the beginning, hundreds are technology companies working for SDN development.

5. Conclusions

Because traditional networks are complex, they are difficult to manage. The development of cloud services is difficult in the traditional way of managing networks. Software-defined networks create the ability to make network management easier and smarter. They separate the control and information planes of the network architecture and include centralized network management. It enables network management to be done directly by the applications using the API, without needing to know the network architecture in detail. Along with the wonderful ideas that are embedded in the SDN, there are new challenges related to the reliability, scalability and security of SDN.

References

[1] R. Presuhn, *Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)*. 2002.

[2] A. Ghodsi, S. Shenker, T. Koponen, A. Singla, B. Raghavan, and J. Wilcox, "Intelligent design enables architectural evolution," *Proc. 10th ACM Work. Hot Top. Networks, HotNets-10*, 2011.

[3] B. Raghavan, T. Koponen, A. Ghodsi, M. Casado, S. Ratnasamy, and S. Shenker, "Software-defined internet architecture: Decoupling architecture from infrastructure," *Proc. 11th ACM Work. Hot Top. Networks, HotNets-11*, pp. 43–48, 2012.

[4] N. Feamster and H. Balakrishnan, "Detecting BGP configuration faults with static analysis,"

2nd Conf. Symp., pp. 43–56, 2005.
[5] K. Greene, "TR10: Software-defined Networking," *MIT Tech Review 10 Breakthrough Technologies*, 2009. [Online].
Available:
http://www2.technologyreview.com/article/412194/tr10-software-defined-networking/.
[6] D. Kreutz, F. M. V. Ramos, P. E. Verissimo, C. E. Rothenberg, S. Azodolmolky, and S. Uhlig, "Software-defined networking: A comprehensive survey," *Proc. IEEE*, vol. 103, no. 1, pp. 14–76, 2015.
[7] H. Jamjoom, D. Williams, and U. Sharma, "Don't call them middleboxes, call them middlepipes," *HotSDN 2014 - Proc. ACM SIGCOMM 2014 Work. Hot Top. Softw. Defin. Netw.*, pp. 19–24, 2014.
[8] N. McKeown *et al.*, "OpenFlow: enabling innovation in campus networks," *ACM SIGCOMM Comput. Commun. Rev.*, vol. 38, no. 2, p. 69, 2008.
[9] S. Schenker, "The future of networking and the past of protocols," 2011.
[10] Statista 2019, "Software-defined networking (SDN) market size worldwide from 2013 to 2021," 2019. [Online].
Available:
https://www.statista.com/statistics/468636/global-sdn-market-size/.
[11] S. Central, "How big is The SDN Market?," 2016. [Online].
Available:
https://www.sdxcentral.com/reports/sdn-market-size-infographic-2013.
[12] I. GlobeNewswire, "Software Defined Networking (SDN) Market Size," 2019. [Online].
Available:
https://www.globenewswire.com/news-release/2019/04/04/1797303/0/en/Software-Defined-Networking-SDN-Market-Size-USD-59-Billion-by-2023-Growing-at-Massive-CAGR-of-42-41.html.

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Bulgaria Communications Chapter

ИЗИСКВАНИЯ ЗА ОФОРМЯНЕ НА СТАТИИТЕ ЗА СПИСАНИЕ "КОМПЮТЪРНИ НАУКИ И ТЕХНОЛОГИИ”

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