RADIOELECTRONICS

&

INFORMATICS

CONTENTS

The Efficiency Analysis of Collaborative Computer-Aided Design

Olga Lebedieva, Oleh Matviykiv, Mykhaylo Lobur

Abstract — **In this paper the main components of collaborative distributed CAD, the basic requirements to realization of collaborative distributed CAD levels, collaborative project management model and collaborative project efficiency parameters are given.**

Index Term s — **collaborative project, project management model, collaborative project efficiency.**

I. INTRODUCTION

The term "collaborative design" becomes today the key technique in CAD/CAM/CAE for complex product development, especially for highly complicated multidisciplinary objects and systems. Last decade several collaborative methodologies have been developed and proposed by scientific groups and CAD vendors as well. Nevertheless the high importance and necessity, these tools and systems still didn't receive wide popularity among design engineers and users. The main reason is low collaborative project efficiency because of discrepancy between distributed project management methodologies, CAD-based collaborative design tools and project workflow requirements.

The purpose of any engineering design project is creation of the set of project documentation according to the specification requirements and workflow standards. Usually, special software tools for workflow planning and project management are applied for these purposes. Distributed teams especially heavily rely on IT technology, which supports many communicative and collaborative processes. Project management software must include a set of tools that help to plan work based on time, resource and cost estimates for a range of works [1-3]. In CAD collaborative design process, all project management tools have to be included directly in collaborative Design Environment with minimal added overhead. Thus, among regular project management tasks, in distributed collaborative CAD it become necessary to choose and set such project parameters, which will maximize the project efficiency and design output.

Olga Lebedieva is with Computer-Aided Systems Department, Lviv National Polytechnic University, 12 Bandera St., 79013 Lviv, Ukraine (corresponding author phone: +38 (067) 346-21-30, +38 (032) 258-26-74, e-mail: lebedeva@polynet.lviv.ua).

Oleh Matviykiv - olehmatv@polynet.lviv.ua

Mykhaylo Lobur - mlobur@polynet.lviv.ua

II. DISTRIBUTED COMPUTER-AIDED DESIGN

A specific feature of distributed collaborative CAD is a presence of separated structural units (teams or persons), which are responsible for definite project parts and its functionality. Each unit of a distributed team adds a distinct set of knowledge and experience to the design process.

The main components of distributed CAD are [4]:

– Personal engineer work stations (with different instrument platforms and operating systems);

– Distributed calculable modules which give calculable resources;

– Distributed data bases and knowledge bases;

– Joint collaborative environment for project coordination between engineering groups;

– Industrial CAD tools for direct designing of project parts or whole object.

All components can be physically and geographically distributed and linked between itself by communication sub-system via Internet/Intranet/Extranet networks.

Usually, such distributed collaborative system can be divided into several hierarchical levels. The basic requirements to realization of different CAD levels are:

– Association of various Hardware CAD facilities in a unique infrastructure (creation of the unique distributed environment for the compatible resource use in dynamic virtual organizations).

– Scale which allows the dynamic grant of calculable powers for the problem decision.

– Providing the reliability and fault tolerance of design process (tracking of the task state so that in the case of death one or a few units in a calculable pool, design process will not suffer).

– Providing safety and data confidentiality (the safety context must be related to the task or data and to provide them such safety services as integrity, confidentiality, authentification and authorizing) [5].

– Storage, access grant and treatment of enormous data content in many additions without their physical moving between calculable resources).

– Heterogeneity (using of heterogeneous resources and creating of calculable environments with using different instrument room platforms and operating systems).

III. Requirement Analysis in Collaborative CAD

In the distributed collaborative design each member will develop distinct ideas and opinions concerning project goals, task priority, and other key decisions. In poorly coordinated teams its members usually focused on individual tasks and not able to work as a cohesive unit. In well-coordinated teams, on the contrary – members are focused on the project object, as a whole.

Project management necessity, namely coordination necessity of the use of human and material resources during the project life cycle by modern methods and management technique to achieve the income proper level of project participants, high product quality, which related to mass growth of scales and project complication, requirements to the terms of their realization, quality of executable works.

Project important element is his environment, in which project arises up, there is and finished. Project environment are the influence factors on his preparation and realization. They can be divided into internal and external.

The political economic, public, legal, scientific and technical, cultural and natural factors belong to external.

The factors related to project organization belong to internal. Project organization is a distribution of rights, responsibility and duties between the project participants.

As a rule, successful completion of large projects depends on performer ability to decide large tasks which seem difficult from the organizational point of view, and to divide them into the row of organizationally less intricate problems separate. There are a few factors which are general for the similar type tasks. Experience shows that the most essential factors are:

--design management process;

--distributed data management between the work performers;

--construction space management and control their mutual allocation.

A. Design management process

Every organization has an own, already formed design technology, which came from the specific industry features. Therefore design process management systems must adapt to the terms of project organizations. It allows co-operating with existent CAD without the change of the formed structure and without the losses of time effectively. And it is achieved by the module of distributed CAD, which provides maximal flexibility and efficiency of project work implementation.

B. Distributed data management between the work performers

It is necessary, that project information was constantly synchronized, represented actual information and was accessible for all members of project group for large projects. The checking system gives an opportunity to the users to decrease time of data verification and considerably to shorten time of project development in the conditions of simultaneous work of a few distributed designer groups.

Project time development diminishes due to the presence of dynamic flow lines between the technological drafts and project database, which also allows making operative alterations in the design process. In addition, users which are busy at development of certain drafts can instantly take advantage of reference project data that are on other sites.

C. Construction space management and control their mutual allocation

The necessity of the spatial component object location management is the fundamental requirement at the MEMS design. Design objects can be parted on separate components which are distributed between a few groups of designers by CAD. The level of responsibility is set for each group.

Basic descriptions of project management systems:

--automation possibility of the territorial distributed industrial enterprises and project organizations of a different specialization;

--operative receipt of analyst reports both on one project and on organization on the whole;

--flexible distributing of access rights to data and reports for the users of the system;

--the system must provide high data protection from the unauthorized division, physical and logical data saving and simultaneous work of large number of users;

--supporting the most widespread operating systems (MS Windows NT, MS Windows 95/98/2000, Novell NetWare); easy bearable;

--openness to development of programmatic complex in connection with the changes of standards and readiness to the dialog with clients on the revisions of the system;

--accordance to the domestic and foreign standards;

--project work term control, reports about the project work state;

--history of all engineering changes in a project;

--integration with the external systems of e-mail;

--saving of variants which did not enter in a basic project.

IV. Collaborative Project Management Model

Today, traditional project management methods are not sufficient to manage multiple tasks in the design and development. They do not include all sources of change, interaction problems and the need for distributed planning. They also do not provide proper notice of changes.

Today's distributed project management tools are still based on a model of planning for a single user, and notification of changes must be specified by users.

Development of collaborative project management (CPM) includes:

1) shared distributed design,

2) workflow design management,

3) shared distributed calendar design,

4) modeling for product alternatives,

5) stages: synchronization and coordination, concurrency and consistency.

The basic requirements to realization of different collaborative distributed CAD levels are:

– Association of various Hardware CAD facilities in a unique infrastructure (creation of the unique distributed environment).

– Scale which allows the dynamic grant of calculable powers for the problem decision.

– Providing the reliability and fault tolerance of design process (tracking of the task state so that in the case of death one or a few units in a calculable pool, design process will not suffer).

– Providing safety and data confidentiality (the safety context must be related to the task or data and to provide them such safety services as integrity, confidentiality, authentification and authorizing)

– Storage, access grant and treatment of enormous data content in many additions without their physical moving between calculable resources.

– Heterogeneity [6-7].

Effective management of collaborative projects should:

1) be easy to use, providing collaboration and communication throughout the project or program team, 2) support the entire building life cycle that includes a plan, construction and operating phases [8-10].

CPM should improve communication through the distribution of coordinated reliable information which comes from data modeling, and it is available to participants in the process.

In [11] CPM model was presented (fig. 1), it consists of four main components: the client space, the level of collaborative support, supervision and project management processes and project cycle. Collaborative Software provides an intermediate level of communication between the main components and instruments to their limits.

Input system data includes goals, mission, future specification requirements, budget, team and time. Final results of the system include product, message, processes and metrics. Considering the more input data and final results, the participants have more design metrics to clearly specify what resources are available, what requirements have to consider, and what criteria products must meet. Analysis of input data and final results will help plan the

entire project on a detailed level, initially in the project life cycle.

To justify the use of CPM model for collaborative design will use a software system "CHOICE". We use such evaluation criteria: project time (0,072), project complexity (0,093), collaborative support (0,290), project efficiency (0,290), number of participants (0,023), project cost (0,102), input / output data (0,121).

So, it is required easy to use solutions that simplify collaboration, communication and the entire life cycle during managing a collaborative project. They provide effective collaborative project management and allow companies to complete projects on time and within budget.

The advantage is that project information is stored in one place, centralizing documents, drawings, communications, contracts, lists, budgets and forecasts, messages, etc. In addition, collaborative project management automates the process of project management, communication flow and cooperation in teams through a project life cycle.

V. EFFICIENCY ANALYSIS OF COLLABORATIVE CAD

In [12] the author selected the main set of project parameters, which were used in corresponding state equation of project:

$$N \times T = \frac{(S - R) \times D}{P} \qquad (1)$$

where T – project time, N – number of project participants, P – team productivity, S – project size, D – project complexity, R – project reuse.

In case of distributed collaborative design, when complete CAD project is divided on several parts and distributed among several teams, the significant impact on its efficiency has stakeholder's collaboration. To support this effect, we propose to modify the project efficiency (*E*) by adding collaborative parameter "*C*":

$$E = N \times T \times C \qquad (2)$$

Thus, the project state equation changes its view into:

$$N \times T \times C = \frac{(S - R) \times D}{P} \qquad (3)$$

As it was mentioned, this representation does not depend on the application field of the project, because all engineering projects have the same set of parameters.
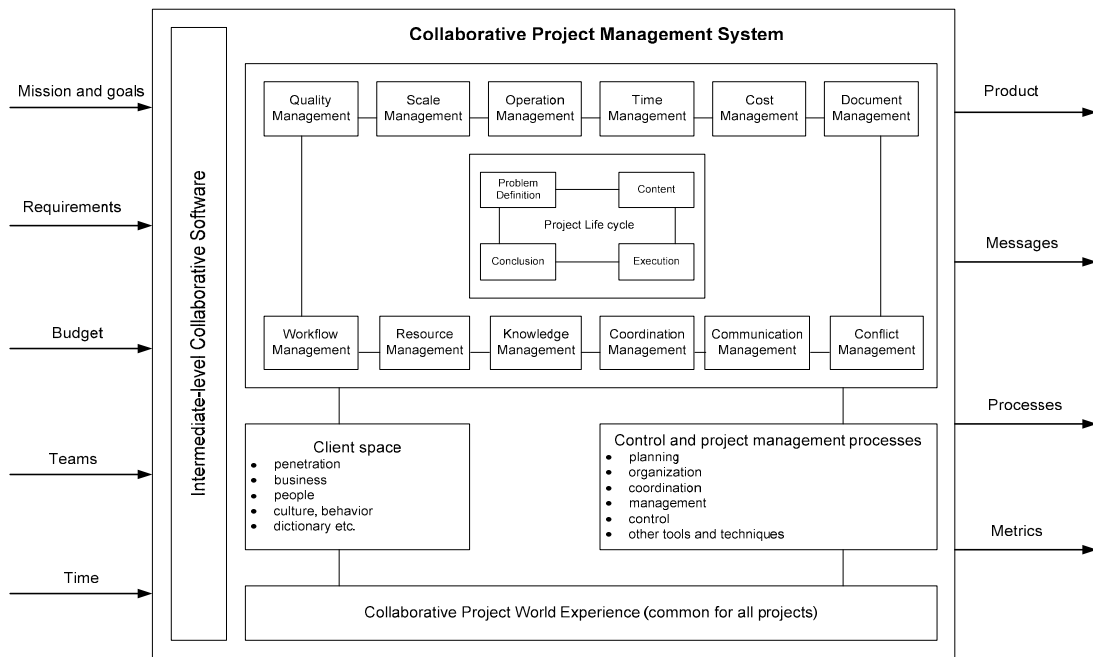
Fig. 1. Collaborative project management model

VI. APPLICATION OF EFFICIENCY ANALYSIS

In order to test collaborative influence, let's calculate the project efficiency by the formulas (2) and analyze the project balance (3) on the example of sportswear collection distributed design with the help of custom-developed Fashion Office Software. The calculation results give in the table below:

T	N	P	S	D	C	E
4	50	5	250	1,6	0,4	80
4	40	6,25	250	1,6	0,4	64
4	50	5	250	1,8	0,45	90

Really, in this case any change of the one of parameters leads to unpredictable chain changes of other parameters.

In [12] the author had developed a set of approaches for analyzing the influence of main project parameters on project efficiency. In case of distributed collaborative design the most interesting is the change of project duration from the point of view of project goals and priorities when the project size is constant and fixed.

For this analysis it was introduced a new variable – the power of the team H as the product of team size N and team productivity P. In case, when we have n distributed teams, this equation will looks like:

$$H = \sum_{i=1}^{n} N_i \times P_i . \qquad (4)$$

This introduction of the new variable (team power H) allows representing the project complexity W in the form of the product of the team power and total project duration:

$$W = T \times \sum_{i=1}^{n} \left(N_i P_i \right) . \qquad (5)$$

According to the above mentioned approach, we have built the relation between teams power (H) and total project time (T) for three projects with different complexity Fig. 2.
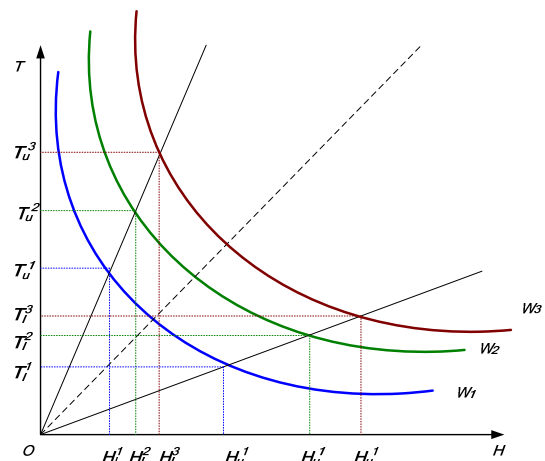
Fig. 2. Project quantity (complexity) changes of distributed collaborative project in time-power coordinate space

Recognizing the importance of the collaborative project efficiency, the experts, however, has not yet agreed on the method of calculating its value [13]. It is believed that along with the main project parameters, which influence on the project effectiveness, one can use various partial parameters. For instance, to calculate the total value of project efficiency, which incorporates the quality of work,

one may use following formula:

$$E = \frac{W}{N} \times Q \qquad (6)$$

where W – the amount of project work (or complexity), N – number of employees, Q - Quality of work.

Besides this one, as additional partial indicators of project efficiency may be included:

– work productivity and its change;

– percentage change in production due to changes in the intensity indicator;

– qualifications of the project teams;

– communication data;

– efficient of time use and others.

VII. CONCLUSION

In this paper the basic requirements to realization of collaborative distributed CAD levels, collaborative project management model and collaborative project efficiency parameters were provided.

Thus, the modified state equation of project proposed in can be applied to collaborative distributed project management in clothing CAD. Its application may improve the project organization of clothing companies. For example, it shows that: if project number of participants N is increasing, team productivity P increases too, but project efficiency E decreases; with increasing project complexity D increases a collaborative support C and project efficiency E, etc.

In calculating the collaborative project efficiency, besides main project parameters, it would be ideal, if calculating technique would allow us to:

– Estimate social relationships between project teams;

– Consider the commensurability of the general and partial indicators of the project efficiency;

– Consider relationship between the quantity and quality of collaborative work.

These items are the main aim of future research.

VIII. REFERENCES

[1] Schafer D.F. Management of software projects: the achievement of optimum quality at the lowest cost / D.F. Schafer, R.T. Fatrell, L. Schafer. - Moscow: Publishing House "Williams", 2003. - 1136 p.

[2] Project Management Guide. Version 2.0 Department of Veterans Affairs Office of Information and Technology Project Management Guide March 3, 2005.

[3] Jenkins N.A Project Management Prime / Nick Jenkins : http://www.nickjenkins.net .

[4] Velichkevych C. Distributed CAD using Grid technologies services / Velichkevych S., and A. Petrenko. - Scientific Bulletin of Technical University "Kyiv Polytechnic Institute". - 2004. - № 3. - C. 30-37

[5] Demchenko Y. Security Architecture for Open Collaborative Environment / Y.Demchenko, L.Gommans, B.Oudenaarde, A. Tokmakoff, M. Snijders, R. Buuren // Proceedings of the European Grid Conference, EGC. – Amsterdam, The Netherlands. – February 14-16, 2005. – Volume 3470.

[6] Steinberg P. Java and .NET Both Bring Something to the Party / P. Steinberg, S. Agarwal, G. Vorobiov: www.devx.com/Intel/Article

[7] Lebedev A.A. Managing the design process in an environment of distributed CAD / O. Lebedev, A. Matviykiv // Bulletin of the National University "Lviv Polytechnic", "Computer systems design. Theory and Practice."- 2007. - № 591. - P. 16-21.

[8] Romano N. C. Collaborative Project Management Software // N.C.Romano, F.Chen, J.F.Nunamaker, Proceedings of the 35th Annual Hawai'i International Conference on Systems Sciences. – Wikoloa Village Kona, Hi, 2002.

[9] Autodesk Communication as a Strategic Tool Connect People, Information, and Processes throughout the Building Lifecycle Annual Survey of Owners, 2005, FMI/CMAA.

[10] Wilson G. D. On-Demand Collaborative Project Management / G. D. Wilson, E. TenWolde.

[11] Lebedeva O. Collaborative Project Management Model / O. Lebedeva, O. Matviykiv, M. Lobur // Proc. of the International Conference CSE. – Lviv, 2010.

[12] Barseghyan P. Principles of Top-Down Quantative Analysis Projects. Part 1 : State Equation of Projects and Project Change Analysis / P. Barseghyan. – PM World Today. – May 2009. – Vol. XI. – Issue V.

[13] Mishra A., Sinha K., Thirumalai S. Comparative Evaluation of Efficiency across Distributed Project Organizations: A Stochastic Frontier Analysis. // Advancing the Study of Innovation and Globalization in Organizations (ASIGO) Conference, May 28-30 2009, Nurnberg, Germany.

Prof. Mykhaylo Lobur is a Head of the Computer-Aided Systems Department of Computer Science and Information Technology Institute of Lviv Polytechnic National University.

Date of his birth is 01.11.1954, Lviv (Ukraine).

Education and Degrees Received:

--1972-1977 – Speciality: "Designing and Producing of radio apparatus", Qualification: engineer-designer-technologist, Lviv Polytechnic Institute, Lviv (Ukraine);

--1986 – PhD in "Computer Aided Design", Institute of Precision Mechanics and Optics (Leningrad, Russia);

--1990 – Associate Professor, CAD Department at State University "Lviv Polytechnics", Lviv (Ukraine);

--2004 – Doctor in "Computer Aided Design", National Technical University "Kyiv Polytechnic Institute" (Kyiv, Ukraine);

--2004 – Professor of Computer Aided Systems Department, Lviv Polytechnic National University, Lviv (Ukraine).

Professional Activity:

--1977 - 1982 – Research fellow, Lviv Polytechnic National University, Lviv (Ukraine);

--1982 - 1984 – Assistant, Lviv Polytechnic National University, Lviv (Ukraine);

--1984 - 1986 – Lecturer, Lviv Polytechnic National University, Lviv (Ukraine);

--1987 - 1993 – Associate Professor, Lviv Polytechnic National University, Lviv (Ukraine);

--1993 - 2001 – Dean of Computer Faculty, Associate Professor, Lviv Polytechnic National University, Lviv (Ukraine);

--2005 - 2008 – Director of Lviv Radio Engineering Research Institute, Lviv (Ukraine);

--2000 - present – Head of Computer Aided Systems Department, Professor, Lviv Polytechnic National University, Lviv (Ukraine);

--2005 - present – Associate Professor, Lviv Polytechnic National University, Lviv (Ukraine).

Research interests are Computer-Aided Design of MEMS devices and processes, organizational aspects of technological design.

More than 350 publications, including 6 textbooks, methodological manuals, scientific-research papers and conference proceedings.

Dr. Oleh Matviykiv is a Associate Professor of Computer-Aided Systems Department of Computer Science and Information Technology Institute of Lviv Polytechnic National University.

Date of his birth is 13.03.1965, Lviv (Ukraine).

Education and Degrees Received:

--1982 – 1983, 1985 – 1989 – Engineer-technologist of Radio-electronic Equipment, Lviv Polytechnic Institute, Lviv (Ukraine);

--1990 – 1993 – Ph.D. student: Microelectronic Department at State Electrotechnical University, St.Petersburg (Russia);

--1995 – Ph.D. in Computer-Aided Design, Lviv Polytechnic State University, Lviv (Ukraine).

Professional Activity:

--1989 - 1990 – Hardware Engineer, Scientific-Research Institute of TV Technologies, Lviv (Ukraine);

--1993 - 1994 – Software and Hardware Engineer, Independent Ecological Laboratory Ltd, Lviv (Ukraine);

--1994 - 2000 – Assistant Lecturer, Lviv Polytechnic National University, Lviv (Ukraine);

--2001 - 2004 – Professor Assistant, Lviv Polytechnic National University, Lviv (Ukraine);

--2005 - present – Associate Professor, Lviv Polytechnic National University, Lviv (Ukraine).

Research interests are Design and programming of commercial software, Development of complex information systems, Modeling simulationd and analysis of complex processes, Automated design of microfluidic MEMS in CAD/CAM/CAE.

More than 50 publications, including 3 textbooks, methodological manuals, scientific-research papers and conference proceedings.

Dr. Olga Lebedieva is a Assistant of Computer-Aided Systems Department of Computer Science and Information Technology Institute of Lviv Polytechnic National University.

Date of her birth is 16.11.1979, Lviv (Ukraine).

Education and Degrees Received:

--1997 - 2002 – Master Degree in International Management, Lviv Polytechnic National University, Lviv (Ukraine);

--2006 - 2009 – Ph.D. student, Computer-Aided Systems Department, Lviv Polytechnic National University, Lviv (Ukraine);

--2010 – Ph.D. in Computer-Aided Design, Lviv Polytechnic National University, Lviv (Ukraine).

Professional Activity:

--2003 - 2006 – Engineer, Information and Statistics Center, Lviv Railway, Lviv (Ukraine);

--2009 - present – Assistant, Computer-Aided Systems Department, Computer Science and Information Technology Institute, Lviv Polytechnic National University, Lviv (Ukraine).

Research interests are Collaborative Design.

More than 25 publications, including methodological manuals, scientific-research papers and conference proceedings.

Metrics of Vector Logic Algebra for Cyber Space

Vladimir Hahanov, *Senior Member, IEEE* , Svetlana Chumachenko, *Member, IEEE,*
Karina Mostovaya

Abstract - **The algebraic structure determining the vector-matrix transformation in the discrete vector Boolean space for the analyzing information based on logical operations on associative data.**

Keywords - **vector-matrix transformation, discrete vector Boolean space, information analysis.**

I. INTRODUCTION

THE purpose of this article is significant decreasing the analysis time of associative data structures through the developing metrics of vector logic algebra for parallel implementation of vector operations on dedicated multiprocessor device. The problems are: 1. Develop a signature, satisfying a system of axioms, identities and laws for the carrier, which is represented by a set of associative vectors of equal length in the logic vector space. 2. Create a signature of the relations for the carrier, represented by a pair: an associative vector – an associative matrix. 3. Develop a signature of the transformations for the carrier, represented by a pair of associative matrices of equal length.

The research subject is the algebraic structures and logic spaces, focused to creating the mathematical foundations of effective parallel computing processes, implemented in a multiprocessor dedicated product.

References: 1. Technologies for parallel computing by dedicated multiprocessor systems [1-2, 10, 11, 15]. 2. Algebraic structures, focused to creating a mathematical apparatus for parallel computing [3-4, 7-10]. 3. Process models for the solving real-world problems on the basis of effective parallel computing [5, 6, 11, 13].

II. B-METRIC OF THE VECTOR DIMENSION

Vector discrete logic (Boolean) space determines the interaction of objects through the use of three axioms (identity, symmetry and triangle) forming a nonarithmetic B-metric of vector dimension:

$$B = \begin{cases} d(a,b) = a \oplus b = (a_i \oplus b_i), i = \overline{1,n}; \\ d(a,b) = [0 \leftarrow \forall i (d_i = 0)] \leftrightarrow a = b; \\ d(a,b) = d(b,a); \\ d(a,b) \oplus d(b,c) = d(a,c), \\ \oplus = [d(a,b) \wedge \overline{d}(b,c)] \vee [\overline{d}(a,b) \wedge d(b,c)]. \end{cases}$$

Vertices of the transitive triangle (a,b,c) are vectors (Fig. 1), which identify the objects in the n-dimensional Boolean B-Space; the sides of triangle d(a,b), d(b,c), d(a,c) are the distances between vertices, which are also represented by vectors of the length n, where each bit is defined in the same alphabet as the coordinates of the vectors-vertices.
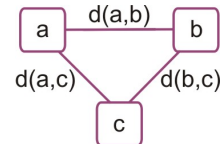
Fig. 1. Triangle of the vector transitive closure

Vector transitive triangle is characterized by complete analogy with the numerical measurement of the distance in the metric M-space, which is specified by the system of axioms, determining the interaction between one, two and three points of any space:

$$M = \begin{cases} d(a,b) = 0 \leftrightarrow a = b; \\ d(a,b) = d(b,a); \\ d(a,b) + d(b,c) \geq d(a,c). \end{cases}$$

The specific of metric triangle axiom lies in numerical (scalar) comparison the distances of three objects, where the interval uncertainty of the result – two sides of a triangle can be greater or equal to a third one – not really suitable for determining the exact length of the last side. Removal of this disadvantage is possible only in a logical vector space, which can form a deterministic view for each characteristic of the process or phenomenon state. Then the numerical uncertainty of the third triangle side in a vector logical space takes the form of the exact binary vector, which characterizes the distance between two objects

and is calculated on the basis of knowledge of the distances for the other two triangle sides:

$$d(a,b) \oplus d(b,c) = d(a,c).$$

The three axioms of the determining a metric are redundant, at least for the vector space, where a single axiom can be used – the interaction between three points: $d(a,b) \oplus d(b,c) \oplus d(a,c) = 0$. Two identities are followed from this law, which determine the relations between one and two points in a space:

$$d(a,b) \oplus d(b,c) \oplus d(a,c) = 0 \rightarrow \begin{cases} d(a,b) = d(b,a) = 0 \rightarrow c = \varnothing; \\ d(a,a) = 0 \rightarrow \{b,c\} = \varnothing. \end{cases}$$

The following fact is interesting. Having regard to the cyclical nature of the triangle, for any two known adjacent (incident) components the third one can be calculated. This concerns both to states (codes) of vertices and to the distances between them:

$$\begin{cases} d(a,b) = d(a,c) \oplus d(b,c) \\ d(b,c) = d(a,b) \oplus d(a,c) \\ d(a,c) = d(a,b) \oplus d(b,c) \end{cases} \begin{cases} d(b,c) = b \oplus c \\ d(a,c) = a \oplus c \\ d(a,b) = a \oplus b \end{cases} \begin{cases} a = d(a,b) \oplus b \\ b = d(b,c) \oplus c \\ c = d(c,a) \oplus a \end{cases}$$

Isomorphism of the set theory concerning the algebra of logic allows determining the vector set-theoretic S-space, where the triangle axiom is defined by symmetric difference Δ, which is analogous to the operation XOR in Boolean algebra:

$$S = \begin{cases} d(a,b) = a \Delta b = (a_i \Delta b_i), i = \overline{1,n}; \\ d(a,b) = [\varnothing \leftarrow \forall i (d_i = \varnothing)] \leftrightarrow a = b; \\ d(a,b) = d(b,a); \\ d(a,b) \Delta d(b,c) = d(a,c), \\ \Delta = [d(a,b) \cap \widetilde{d}(b,c)] \cup [\widetilde{d}(a,b) \cap d(b,c)]. \end{cases}$$

Here Δ is the symmetric difference operation on the four-digit set-theoretic alfabet $\alpha = \{0,1,x = \{0,1\}, \varnothing\}$, represented by the following table:

Δ	0	1	x	$\varnothing$
0	$\varnothing$	x	1	0
1	x	$\varnothing$	0	1
x	1	0	$\varnothing$	x
$\varnothing$	0	1	x	$\varnothing$

When determining the distance between two vectors in the S-space the symmetric difference is used, which is isomorphic to the XOR-operation in the Boolean B-space. Examples of calculating the distances between vectors in both spaces (S, B) are given below:

	a	1	0	0	0	1	0	0	1
	b	x	x	0	0	1	1	0	0
	c	x	x	x	x	0	0	0	0
S =	d(a,b)	0	1	$\varnothing$	$\varnothing$	$\varnothing$	x	$\varnothing$	x
	d(b,c)	$\varnothing$	$\varnothing$	1	1	x	x	$\varnothing$	$\varnothing$
	d(a,c)	0	1	1	1	x	$\varnothing$	$\varnothing$	x

	a	1	0	0	0	1	0	0	1
	b	1	1	0	0	1	1	0	0
	c	1	1	1	1	0	0	0	0
B =	d(a,b)	0	1	0	0	0	1	0	1
	d(b,c)	0	0	1	1	1	1	0	0
	d(a,c)	0	1	1	1	1	0	0	1

Vector equal to zero (empty set) for all coordinates means a full match the response and query. As well as the vector equal to 1 (symbol x) for all digits indicating complete contradictoriness the response and query. Number of gradations for a variable can be a finite number that multiple of a power 2 $\alpha = 2^n \rightarrow \{2^2 = 4, 2^4 = 16\}$, which is determined by the power of the Boolean on the universe of n primitive. Otherwise, the symmetric difference can exist only in closed concerning the set-theoretic operations alphabet. Thus, the interaction of two objects in a vector logical space can have either binary or multi-valued deterministic scale of measuring interaction. Hasse diagram of any finite number of primitives (1,2,3,4, ...) can be packed to a variable of logical vector. Moreover, 16 gradations (for instance) of vector interaction by the four primitives exactly indicate not only the degree of proximity by the variable, but in what way they differ – by some primitives, or their combination. Vector operation XOR actually smooths out the changes in the two codes or vectors, that is of interest for the creating digital filters. If it is applied many times, we can get a binary pyramid, where the last vertex is always the zero vector. Thus, the obtained pyramid makes it possible using some redundancy to correct errors in the process of information transferring. The procedure of convolution distances in order to verify the errors of data transferring for the number of vectors equal degree 2 is presented below. 1) Compute all the distances between the binary codes, including the last and first vectors, resulting in a closed geometric figure $c_i = a_i \oplus a_{i+1} (i = n \rightarrow i+1 = 0)$. 2) Compute all distances between non-overlapping pairs of obtained in the first stage codes $c_i = a_{2i-1} \oplus a_{2i} (i = 1,2,3,...,n)$. 3) Repeat procedure 2 to obtain a package equal to zero in all coordinates. The procedure is illustrated by the following calculations:
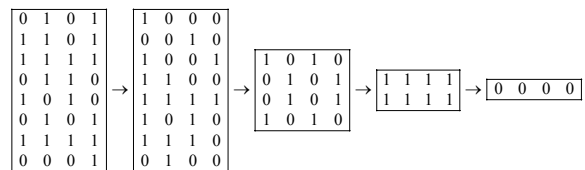
Similar actions can be performed and for multivalued vectors, where, for instance, every coordinate is defined in four-digit set-theoretical alphabet, and the procedure is reduced to the obtaining a vector of empty values coordinates:

$$
\begin{array}{cccc}
0 & x & 0 & 1\\
1 & x & x & 1\\
1 & x & 1 & x\\
0 & 1 & x & 0\\
1 & x & 1 & 0\\
0 & 1 & 0 & 1\\
1 & x & 1 & 1\\
x & 0 & x & 1
\end{array}
\rightarrow
\begin{array}{cccc}
x & \varnothing & 1 & \varnothing\\
\varnothing & \varnothing & 0 & 0\\
x & 0 & 0 & 1\\
x & 0 & 0 & 0\\
x & 0 & x & x\\
x & 0 & x & \varnothing\\
0 & 1 & 0 & \varnothing\\
1 & 1 & 1 & \varnothing
\end{array}
\rightarrow
\begin{array}{cccc}
x & \varnothing & x & 0\\
\varnothing & \varnothing & 0 & 1\\
\varnothing & \varnothing & 0 & x\\
\varnothing & \varnothing & \varnothing & x\\
0 & 1 & 0 & \varnothing\\
1 & 1 & 1 & \varnothing
\end{array}
\rightarrow
\begin{array}{cccc}
x & \varnothing & x & x\\
x & \varnothing & x & x
\end{array}
\rightarrow
\begin{array}{cccc}
\varnothing & \varnothing & \varnothing & \varnothing
\end{array}
$$
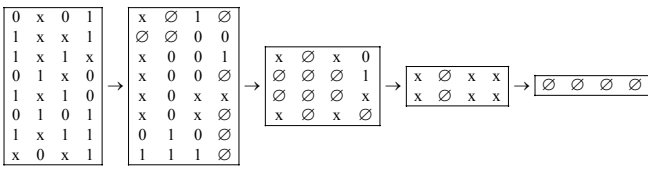
Here it happen a convolution of a closed space to a single point, Fig. 2, defined in all coordinates by symbols of the empty set, by calculating the distance between vector-objects, and then – the distance between the vector-distances. Otherwise, the modulo sum of all vector-distances, closed in the cycle is equal to an empty vector

$$
m_i = c_i \underset{i=1,n}{\overset{j=|i+1|_n}{\oplus}} c_j \rightarrow m = m_i \overset{n-1}{\underset{i=1}{\oplus}} m_{i+1}.
$$

But this procedure is characterized by less error diagnosis depth – the detecting an incorrect bit is possible. While a binary tree of space convolution makes it possible to increase the diagnosis depth up to a vector pair.
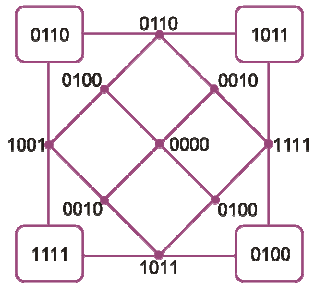

Fig. 2. Closed space convolution

Space convolution is of interest for many real-world problems: 1) Diagnozing and correcting errors when the transmitting information via communication channels. 2) Detecting faults in digital products based on fault detection tables. 3) Searching faults in digital products based on multivalued fault detection tables.

The essence of the space convolution lies in the metric of transitive triangle, which can be transformed by shifting the right side of the equation to the left:

$$d(a,b) \oplus d(b,c) = d(a,c) \rightarrow d(a,b) \oplus d(b,c) \oplus d(a,c) = 0.$$

This definition assign primary importance not elements of the set, but the relations, thereby reducing the system of metric axioms from three to one and to extend its action on an arbitrarily complex structures of n-dimensional space. The classical metric definition for determining the interaction between one, two and three points in a vector logical space is a special case of B-metric when $i = 1,2,3$ respectively:

$$
M = \begin{cases}
d_1 = 0 \leftrightarrow a = b;\\
d_1 \oplus d_2 = 0 \leftrightarrow d(a,b) = d(b,a);\\
d_1 \oplus d_2 \oplus d_3 = 0 \leftrightarrow d(a,b) \oplus d(b,c) = d(a,c).
\end{cases}
$$

In particular, metric, functional and other kinds of spaces in the sum also give zero. For example, a figure with sides 1, 2, 3, according to all the textbooks, is not a triangle, because three points are located in line, Fig. 3. But the axiom of metric transitive closure uses a structure consisting of three points on the plane with different coordinates, which is strictly called a triangle. Then a figure with sides 1, 2, 3, according to the definition of the metric, is a triangle with two zero angles and the third one, equal to 180 degrees, where all the conditions for the three sides are met: $a + b \geq c \rightarrow 1 + 2 = 3$.
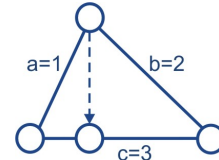
Fig. 3. Metric triangle

III. Conclusion

Information vector logic space as a subset of a metric one determines the interaction between a finite numbers of objects by means of the introduced definitions, axioms of identity, symmetry and transitivity of the triangle. At that the last property degenerates into a strict equality, which makes it possible potentially to reduce by a third volume of binary information about the interaction of objects, due to the convolution of any closed logical space in the zero-vector.

Beta-metric of a vector logic space, presented by a zero-sum of cycle distances of binary codes, creates a fundamental basis for all logical and associative problems of synthesis and analysis related to the searching, recognition and decision-making.

Based on the beta metric and the three quality criteria of interaction between vector logical objects in the same space a beta-criterion is created. It makes it possible to determine effectively, accurately and adequately the quality of object interaction, when searching, pattern recognition and decision-making by calculating the xor-function.

Algebra of vector logic creates an infrastructure mathematical service of a vector logical space for the solving real-world problems of synthesis and analysis. It consists of three components: vector, vector-matrix and matrix algebraic structures. Signature of algebras is given by a standard set of logical vector operations AND, OR, NOT, XOR to determine the interaction between compatible objects of a carrier, which form a binary n-dimensional vectors and compatible by the dimension matrix.

V. References

[1] M.F. Bondarenko, Z.V. Dudar, I.A.Ephimova, V.A. Leshchinsky, S.Yu. Shabanov-Kushnarenko. About brain-like computers // Radielectronics & Informatics.– Kharkov: KHNURE.– 2004, No 2.– P. 89–105.
[2] Cohen A.A. Addressing architecture for Brain-like Massively Parallel Computers / Euromicro Symposium on Digital System Design (DSD'04).– 2004.– P. 594-597.

[3] Kuznetsov O.P. Fast brain processes and pattern recognition // News of artificial intelligence.– 1998.– No2.

[4] Vasilyev S.N., Zherlov A.K., Phedosov E.A., Phedunov B.E. Intellectual control in dynamic systems.– M.: Physico-mathematical literature.– 2000.– 352 p.

[5] Lipaev V.V. Software ingeneering. The methodological fundamentals. Textbook.– M.: Teis.– 2006.– 608 p.

[6] I.S. No1439682. 22.07.88. Shift Register / Kakurin N.Ya., Hahanov V.I., Loboda V.G., Kakurina A.N.– 4 p.

[7] Hyduke S.M., Hahanov V.I., Obrizan V.I., Kamenuka E.A. Spherical multiprocessor PRUS for solving the Boolean equations // Radielectronics & Informatics.– Kharkov. 2004. No 4(29). P.107-116.

[8] Digital system-on-chip design and test / V.I. Hahanov, E.I. Litvinova, O.A. Guz. – Kharkov: Novoye Slovo, 2009.– 484 p.

[9] Digital system-on-chip design and verification. Verilog & System Verilog / V.I. Hahanov, I.V. Hahanova, E.I. Litvinova, O.A. Guz.– Kharkov: Novoye Slovo, 2010.– 528 p.

[10] A. Acritas. Fundamental of computer algebra with applications.– M.: Mir.– 1994.– 544 p.

[11] A.V. Attetkov. Optimization Methods.– Bauman Moscow State Technical University.– 2003.– 440 p.

[12] M. Abramovici, M.A. Breuer and A.D. Friedman. Digital System Testing and Testable Design. – Comp. Sc. Press.– 1998.– 652 p.

[13] D. Densmore, R. Passerone, A. Sangiovanni–Vincentelli. A Platform–Based taxonomy for ESL Design // Design & Test of computers.– 2006.– P. 359–373.

[14] Diagnosis automation for electronic devices / Yu.V. Malishenko et al./ Editor V.P. Chipulis.– M.: E, 1986.– 216 p.

[15] Trachtengertz E.A. Computer methods for economic and information managerial solutions.– SINTEG.– 2009.– 396 p.

High-Voltage Current-Controlled Analog Switches for Various Kinds of Application

Mariusz Jankowski

Abstract— **The Paper presents several high-voltage analog switch designs. All of them are current-controlled solutions, which make them highly resilient to high voltage drops of transmitted signals. Possible field of application for all presented structures is discussed.**

Index Terms— **High-voltage circuits, analog switches, current-mode control, current transmission, voltage transmission.**

I. INTRODUCTION

SWITCHES are circuits, used in various types of circuits. They can be used both in analog and digital domain, both for voltage passing and current flow control [1]. In low-voltage use, single MOS type transistor or CMOS transmission gate is usually enough to pass full range of voltages and current flows. Such designs, mainly CMOS gates are widely utilized in logic circuits, e.g. in multiplexers [3].

Also, maximal safe operation voltages between pairs of low voltage transistor terminals are usually similar or identical and usually cover all possible operation voltage range from ground to supply [2]. This often assures that various transistor interconnections are safe by a rule.

Design of high voltage switches is a more challenging task. Important difference between low and high voltage domain is the very construction of such transistors. Low voltage transistors are usually fully symmetrical structures, which means that drain and source terminals are defined by application of such transistors.

In domain of high-voltage MOS devices situation is quite different [4]. First of all, such MOS transistors are structurally asymmetrical, which may lead to some limitations of application. Also, safe operation voltage-range in such devices may significantly differ for different terminals. Most common example is limitation of gate-source voltage to $5 - 5.5$ V, while gate-drain voltage and source-drain voltage may safely reach tens of volts.

Such limitations cause important application troubles for low-voltage-like switches in high-voltage domain. First, such structures are not symmetrical as a high-voltage swing is allowed usually only on one side of the switch, namely gate-drain path. This is not always forbidden, there is a number of tasks for which such structures are applicable. Still, these are not versatile solutions, and they operation must be well checked beforehand or controlled during operation.

Other problem with low-voltage switch adaptation for high-voltage domain is a way of switch control. Classic voltage control cannot be applied in direct way. Some other means of switch control must be applied.

Electric current can be transmitted throughout all voltage range also in high-voltage domain circuits and so it is good way of providing switch control. High-voltage switch itself is MOS-based device and as such requires voltage based control circuitry. This seeming contradiction can be solved with use of a simple current-voltage converter in connection with pass transistor.

Initial structure of high-voltage switch can thus be defined: high-voltage MOS transistor as voltage/current pass device with low-voltage gate-source voltage control module driven with current passing through this control module. Such switch is driven with current source or sources. Owing to this way of control the switch itself can float through most of the voltage-range of the high-voltage circuits.

Proposed switch solutions are tested with use of test benches shown in Fig. 1 and 3.
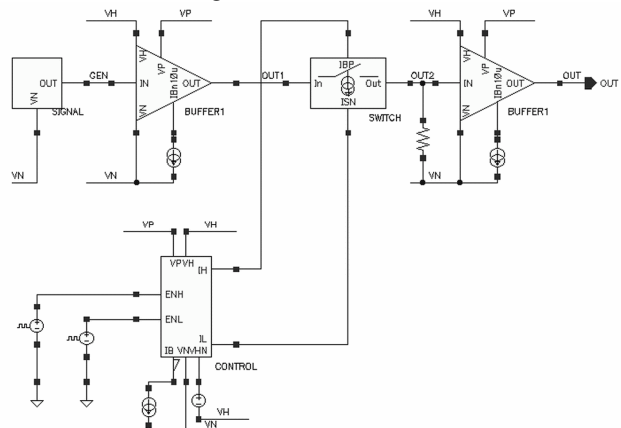
Fig. 1. Voltage-mode switch operation test bench

Voltage mode test bench presented in Fig. 3 consists of analog high-voltage input signal provided to the input of switch under test through voltage buffer (Fig. 2). Output side of the switch is loaded with identical voltage buffer and additionally with one variable resistor for low resistance load simulations.
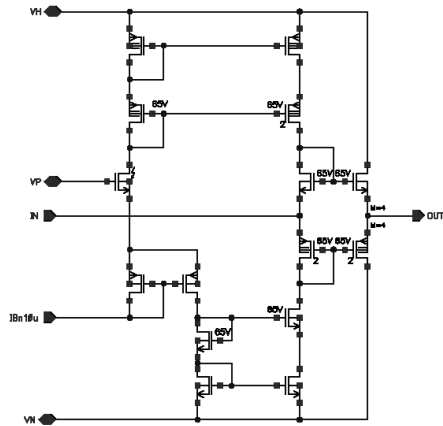
Fig. 2. High-voltage buffer for voltage-mode test bench

Current-mode test bench is presented in Fig. 3. It consists of switch and switch-control circuitry, current source/sink and output voltage source. It simulates low-impedance input of current-mode input stage following the switch.
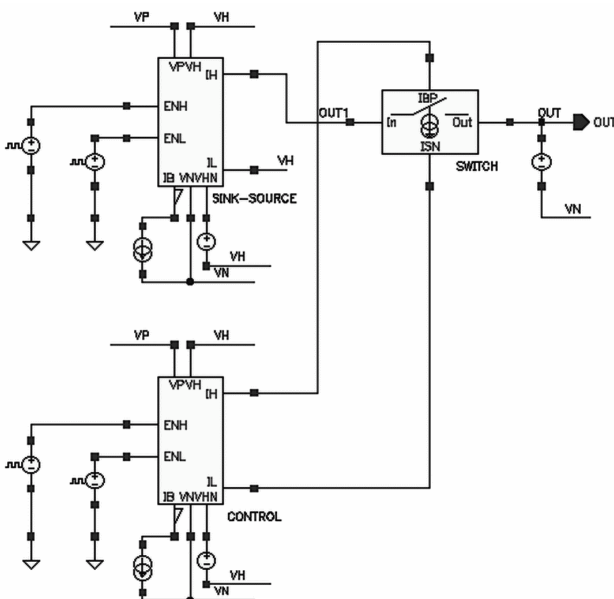
Fig. 3. Current-mode switch operation test bench

II. One Pass-transistor Approach

Proposition of the simplest version of high-voltage switch devised according to above rules is presented in Fig. 4.
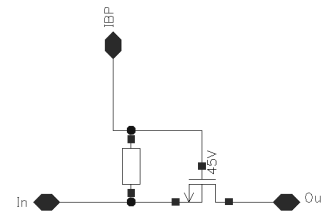
Fig. 4. Simple high-voltage switch structure

This circuit is equipped with one pass transistor and resistor driven with single current source. Resistor is placed on the input side of the switch in order to use output of the stage before the switch as a sink for the switch-driving current. If the driving current is equal 0, switch is open, if proper current goes through the switch resistor, the switch transistor driven with the resistor voltage connects switch input to output. Possible extension of this design is Zener diode placed in parallel with resistor as a safety device. It disables possibility of the pass MOS transistor damage due to possible voltage surge between its gate and source.

Unfortunately, test bench simulations show that such solution doesn't work as expected. Fast transients of the input signal cause the switch to conduct and change voltage level on the resistor added on output side of the switch (Fig. 5).
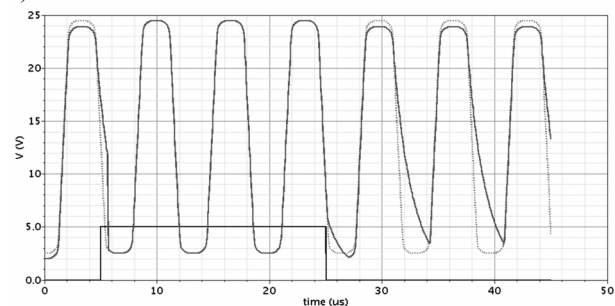
Fig. 5. Voltage-mode operation of the fig. 4 switch

Solution to this problem seems to be a change of input and output sides of the switch. Simulation shows that current forced through the switch is still able to make it conduct. Additionally, the resistor of the switch is buffered from its input side by the gate-drain structure of the passing transistor itself. When the switch goes off, fast transient of the input signal do not turn the switch on and isolation of the switch sides is sustained (Fig. 6). However, it is true only for one specific case, when output side of the switch is connected only to highly resistive input of following stage.
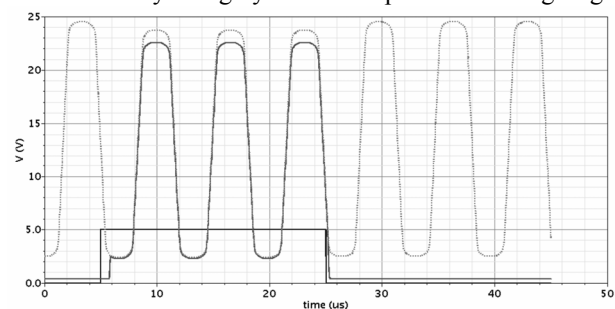
Fig. 6. Voltage-mode operation of the reversed fig. 4 switch

Presence of low-input circuitry on the other side of the switch simply makes it fail.

In practice such situations occurs when a stage at the output of the switch is reconnected to another driving circuitry. In such situation active outputs of low-impedance drivers are present at both sides of the switch. This way the switch again faces a problem of control circuit exposure to the low-impedance driver output, described for its first version. This effect shows drawback of simple asymmetrical one pass-transistor solutions. Similar problems were observed for various one pass-transistor switch variants tested by author. Obtained results show that efficient high-voltage current-controlled switch should be a symmetrical structure.

III. SYMMETRICAL TWO PASS-TRANSISTOR APPROACH

Simplest amendment to the proposed switch, based on analysis of proposed switches, is cascade concatenation of two presented simple switches, leading finally to structure shown in Fig. 7. The switch control resistor is now buffered from both sides by high-voltage MOS transistors and voltage-mode simulation shows its proper operation (Fig. 8).
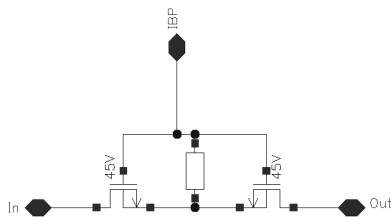
Fig. 7. Simple structure of symmetrical high-voltage switch
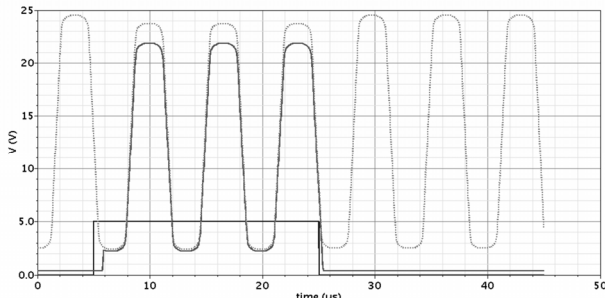
Fig. 8. Proper operation of the fig. 7 switch

Simulation shows that forcing current through resistor placed between can lead to turning the switch on, but still, this switch has another limitation to its operation. It draws all control current from - or sinks it to - the output of the preceding stage, so it can influence operation of such stage unless this stage is robust enough to cope properly with this additional load. Precise current flow switching is also impossible as this switch would source/sink the directed current, falsifying value of processed currents.

This is disappointing conclusion, because one control-current circuitry is not only simpler in design. It is also very handy if the circuit does not offer implementation

possibility for high-side current source with enable functionality.

In such situation a PMOS transistor version of the circuitry with control current by low-side current source would be appreciated solution.

Further in the paper it will be shown that such solutions with better properties are possible.

The problem of current load imposed on preceding stage is significantly minimized in circuits presented in Figure 9. a, b, and c. In all these solutions control current is both sources and sunk by devoted sources.

Owing to this feature, only difference of the control currents is sunk to or sourced from the preceding stage. Still, there is crossing of the signal path and control current, which excludes these solutions from current flow switching tasks.

Circuit shown in Fig. 9.a is direct extension of circuit presented in Fig. 4. Zener diode is a safety device here. Pass transistor driving voltage is decided by current and resistane values.
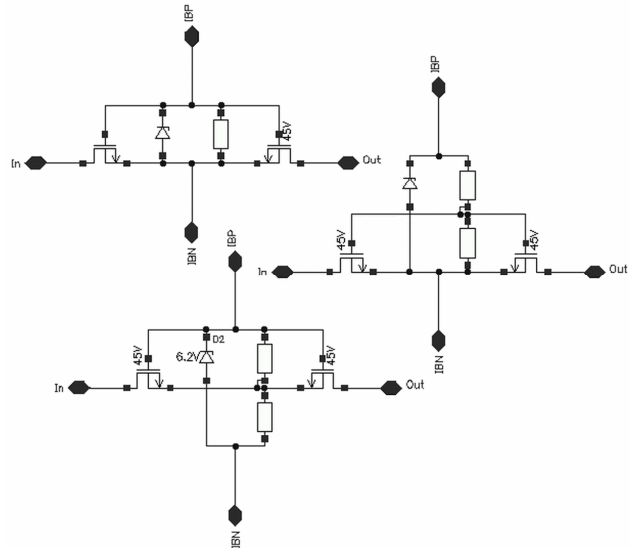
Fig. 9. Two control-current switch (a - upper), diode-controlled switch version (b - middle), optimized diode-controlled switch-version (c - lower)

Circuit in Fig. 9.b is an improved version of the previous solution. It can operate also in case of permanent over-current condition. When it happens, the Zener diode limits voltage drop between its terminals to approximately 6.2V and resistor voltage divider provides only its fraction between gate and source of the pass transistor. This virtue makes possible to use this solution in situation when both control current and resistors value are poorly defined. In such situation the over-current mode control may become primary way of switch control. Excess control-current cause the Zener diode to conduct and stabilize voltage drop on the divider resistors. Fraction of so stabilized voltage used to drive the pass transistor depends on resistance ratio, only. Resistor ratio can be easily controlled with device sizing.

Circuit in Fig. 9.c is an optimized version of the previously presented solution. It makes voltage-range of

switch operation more symmetrically placed in ground-to-supply voltage-range. It is obtained due to improved connection of the resistor divider to the pass transistor.

All switches presented above have same limitation, they cannot be used for current switching due to using signal path as a current or source/sink. This problem can be initially solved with switches that offer control path isolated from signal path. Because control device is connected between gate and source of pass transistors and physically is connected to the signal path, logical solution is using another MOS transistor with gate connected to the signal path, as a switch control device.

Switch presented in Fig. 10.a is the simplest solution of that kind. It offers separation in control-current and signal paths. Moreover, only one control-current is required to control this switch. Simulation shows proper operation of such circuitry, due to proper choice of control transistor and passing transistor. Though, it must be stressed here, there are specific issues related to such connection.

Current-voltage conversion on control transistor is highly nonlinear. It is difficult to obtain high gate-source voltage without using high currents. Switch in Fig. 10.b overcomes this limitation by using additional resistor. Here resistor works as a main current-voltage conversion device and control transistor is mainly a buffer between the resistor and a signal-path. Lower currents are enough to properly drive this circuit.
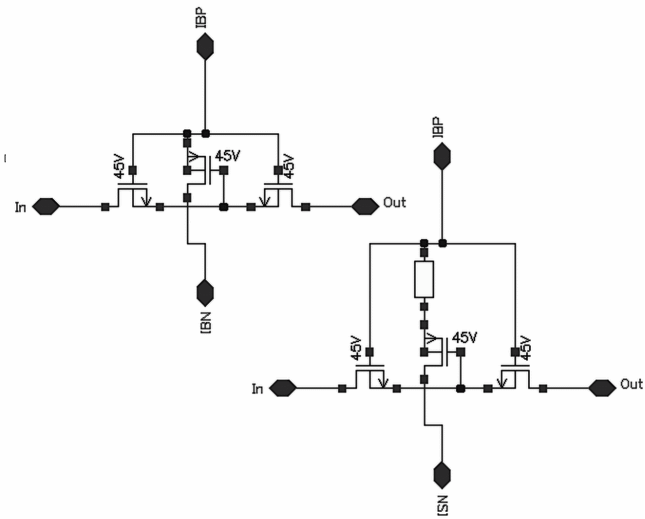
Fig. 10. Current-mode enabled switch (a - upper), improved current-voltage conversion version (b - lower)

Unfortunately, when such switches go off, gate-source voltage of control transistor does not go down to zero. The pass-transistor gate-source voltage is kept close to its threshold voltage value. In specific cases, like fast voltage signal transients or current forced throughout such switches, they might open and thus fail. In conducted simulations these two switches working in current-switching mode behave properly but when turned off they both need much more time to settle down and extinguish currents flowing

throughout them. E.g. Switch presented in Fig. 9.a passing 20 uA current cuts the current down to 2 nA on 600 ns after cut-off signal, while switch in Fig. 10.a needs 180 us to extinguish current to 2 nA. Fig. 11 presents comparison of current flow through the switches 9.a and 10.a, in case of on- to off-state transition.
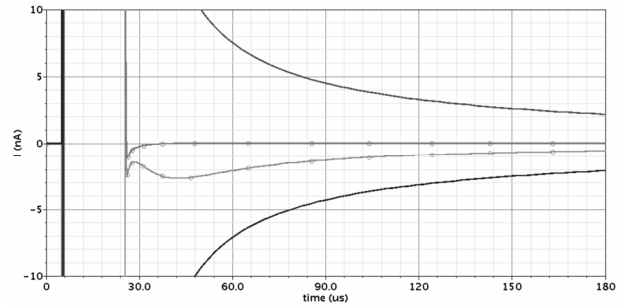
Fig. 11. Comparison of current flowing through 9.a (solid line) and 10.a (solid circle-marked line) switches during switching-off process

Improved versions of switches are presented in Fig. 12. Switch in Fig. 12.a corresponds to Fig. 10.a switch and switch in Fig. 12.b corresponds to Fig. 10.b switch. In both cases cut-off reliability improvement is made by means of high value resistor shorting the control transistor. High value of the resistor ensures low current-leaks while switches are on and gate-source voltage equal 0 during cut-off state.
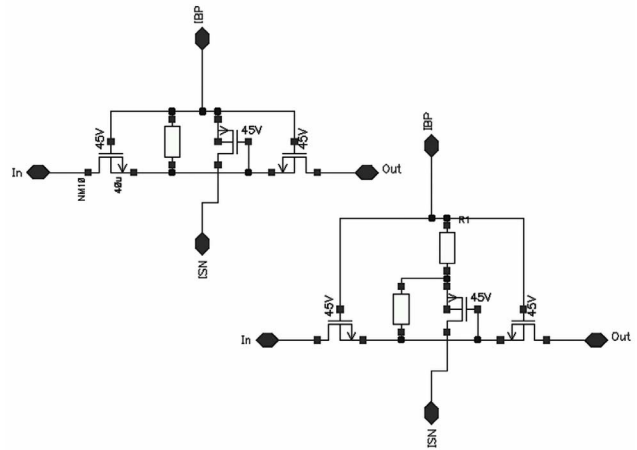
Fig. 12. Complex current-mode enabled switch (a - upper), improved current-voltage control version (b - lower)

The pay-off is lost ability, or at least lost high quality, of current-mode operation due limited current-leaks through the shorting resistor. Still, these switches can be used as reliable circuits in voltage-mode circuitry and they require only one control current and do not cause any problems with entering cut-off state while passing current-mode signals. Other possible drawback is high value of the shorting resistor. Its layout may tend to be large, which is connected with area consumption and large parasitic capacitors.

One more switch structure is presented in Fig. 13. In this case the driving circuitry is a two-stage solution. First stage consists of an MOS transistor and one resistor in series.
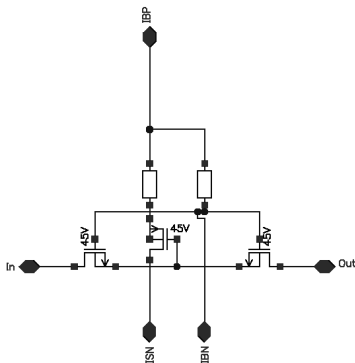
Fig. 13. Two-current controlled complex current-mode enabled switch

This stage is always biased. The other stage is made of resistor connected to the other resistor and pass transistor gates. During the on-state biasing current is forced into resistor placed in series with the MOS transistor, while there is no current flow through the other resistor. During off-state part of biasing current is sunk through the other resistor, which lowers gate-source voltage of the pass transistors to ~ 0 V. Such control mode requires some current flow but this switch can operate in both voltage- and current-mode.

IV. CONCLUSION

In this paper approach to design high-voltage current-controlled switches is presented. Introduced circuits offers different abilities and application fields, which shows ways of optimization, applicable to high-voltage domain analog circuits and systems.

REFERENCES

[1] M. Jankowski, "Trapezoidal Waveform Generation Circuit with Adjustable Output Voltage Range," International Conference CADSM'2007, Polyana, Ukraine, February, 20-24, 2007.
[2] Weize Xu, E.G. Friedman, "Clock feedthrough in CMOS analog transmission gate switches," ASIC/SOC Conference, 2002. 15th Annual IEEE International.
[3] P. Amrozik, P. Kotynia, P. Michalik, M. Jankowski, A. Napieralski, "Alternative Design Approach for Signal Switchboxes in Nanometer Process," Proceedings of the Xth International Conference CADSM 2009, Lviv-Polyana, Ukraine, 24-28 February 2009.
[4] M. Baus, M. Z. Ali, O. Winkler, B. Spangenberg, M. C. Lemme, H. Kurz, "Monolithic Bidirectional Switch (MBS) A Novel MOS-Based Power Device," Proceedings of ESSDERC, Grenoble, France, 2005.

Mariusz Jankowski received the M.Sc. and Ph.D. degrees in electronics engineering from the Technical university of Lodz, Lodz, Poland, in 1998 and 2003, respectively.
He is an Assistant Professor with the Department of Microelectronics and Computer Science at Technical University of Lodz, Poland. His research interests include analysis and design of mixed signal integrated circuits, including high-voltage applications, design of integrated 3D circuits, at present he works on 3D circuits and EMC issues. He is the author or coauthor of more than 30 publications, including two chapters in books.

Evaluation of Computational Complexity
of Finite Element Analysis
Using Gaussian Elimination

Petro Shmigelskyi, Ihor Farmaga, Piotr Spiewak, Lukasz Ciupinski

Abstract— **This paper describes the evaluation of computational complexity of software implementation of finite element method. It has been used to predict the approximate time in which the given tasks will be solved. Also illustrates the increasing of computational complexity in transition from two to three dimensional problem.**

Index Terms— **Finite element methods, Computational complexity, Interpolation, Linear approximation.**

I. INTRODUCTION

THE issue of computational complexity of FEM is especially critical for the analysis of bodies with a very heterogeneous structure [1], described by a huge amount of mesh nodes. Having answered the question and knowing the size of the input data, we can determine whether the task can be solved using available computer, and whether the solution will be obtained in a reasonable time.

II. ASYMPTOTIC NOTATION

The function of computing time complexity in some cases can be determined accurately. In most cases it is not required to find its exact value. The exact value of the time complexity depends on determining the elementary operations (e.g., the complexity can be measured in the number of arithmetic operations, bit operations or operations of Turing machine). When increasing the size of the input data, the contribution of constant factors and terms of lower order, which appear in the expression, is quite

small for the exact work time. Mathematical notation, which allows to reject details of the algorithm analysis, is called asymptotic notation and is denoted by $O(f(N))$; it is the notation that will be used to describe the complexity of algorithms [2].

III. ALGORITHM ANALYSIS

Finite Element Method Algorithm

There are many algorithms for the implementation of the FEM, but they all contain the basic steps shown in Fig. 1.
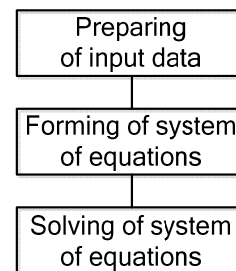
Fig.1 Stages of FEM.

Preparation of input data includes the formation of finite element mesh. We will not evaluate its complexity, as it depends heavily on its generation algorithms: in some cases it may be a simple task, in other its complexity exceeds the complexity of solving the remaining phases of the FEM, as well as in most tasks the mesh is created once and used in many simulations.

Computational complexity

For instance, to conduct the analysis of algorithm complexity, we take the one described in [3]. Here the banded stiffness matrix with bandwidth W is used. The number of nodes is denoted by N, and the number of elements – E.

The formation of global matrices of stiffness and forces is done via the recording of values obtained for individual elements, taking into account boundary conditions. The amount of operations needed for this purpose equals $C \cdot E$, where $C=const$ – the number of operations for the formation of local matrices of one element. In the

asymptotic notation the constant factors are not taken into account, so it will look like:

$$O(E). \qquad (1)$$

Global matrices need modification to incorporate prescribed nodal values. In the worst case the complexity of this phase will be:

$$O(NW). \qquad (2)$$

The next step solves the system of equations. Because of its huge size, the use of FEM without a computer is not reasonable. To solve this problem many different methods are used. In the tested program Gaussian elimination is used, which allows accurate solution of the system. The method implementation is divided into two subroutines. The first one reduces the matrix to upper triangular, its asymptotic complexity is:

$$O(NW^2). \qquad (3)$$

The second finishes the solution of the system, and its complexity:

$$O(NW). \qquad (4)$$

Having added all gained complexities, we obtain expression for the whole algorithm. Given large W, the function of the algorithm will converge to its third member, which is growing the fastest and therefore only considered asymptotic complexity of the whole FEM algorithm is equal to:

$$O(E)+O(NW)+O(NW^2)+O(NW) = O(NW^2). \qquad (5)$$

IV. RESEARCH OF RESULTS

Solution time of two dimensional problem

Having computational complexity of the algorithm we can predict the approximate time in which the given task will be solved. We need to conduct a number of previous tests on the computer to be used. For more accurate prediction these launches are conducted with large input data. Now, knowing the time in which the problem has been solved and its dimensions, a time of solving other tasks can be provided proportionally, through asymptotic complexity. These survey results are presented in Tables I and II, where column *t exp* shows the time of solving of the tasks, obtained experimentally, and column *t pre* – the predicted time. In the Table I the third experiment has been taken as the basis of time prediction, in Table II – the fourth one.

As it can be seen from the Table I, high precision of time prediction is achieved for large values of input data, since the used asymptotic complexity does not consider members of the lower orders, and for large input their impact on the

entire function is small. For more accurate prediction of the solution time, the results of the task, which dimension is the closest to the explored task dimension, has to be taken as the basis. For small input data the full expression of complexity Eq. (5) can be used, and previously rejected factors must be taken into account within each member. However, this assessment does not guarantee high predicting accuracy.

TABLE I
PREDICTED SOLUTION TIME

№	N	W	*t exp*, sec	*t pre*, sec	$\delta, \%$
1	251001	502	536.42	546.93	1.92
2	75 651	502	165.20	164.84	0.22
3	38 160	361	43.00	basis	
4	27 391	302	14.35	21.60	50.52
5	7 360	161	1.12	1.65	47.32

TABLE II
PREDICTED SOLUTION TIME

№	N	W	*t exp*, sec	*t pre*, sec	$\delta, \%$
1	251001	502	536.42	363.34	32.27
2	75 651	502	165.20	109.51	33.71
3	38 160	361	43.00	28.56	33.58
4	27 391	302	14.35	basis	
5	7 360	161	1.12	1.10	1.79

Evaluation of memory usage

Most memory in the program is needed to store the system of equations, which consists of stiffness matrix K, the vector of desired values Φ and vector of forces F (Fig. 2). To store the system we need M_G memory cells:

$$M_G = N(W+2L) \qquad (6)$$

where L is an amount of unknown values in one node.
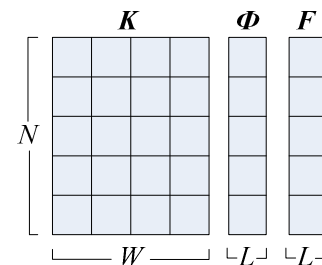
Fig. 2. Presentation of the system of equations in memory

For elements storage using an array that stores numbers of its nodes, the size equals:

$$M_E = n \cdot E , \qquad (7)$$

where n is an amount of nodes in one element. The second array stores the coordinates of nodes; its size is equal to:

$$M_N = d \cdot N , \qquad (8)$$

where d is the dimension of space.

Other expenses of memory are not taken into consideration as they are much smaller and do not depend on input data.

For example, when solving the problem of deformation of plates with one million elements and 500 000 nodes, with the bandwidth of 500, triangular elements with three nodes are used. To store the nodes we use *Long* data type with the size of 4 bytes, and for the coefficients of equations and nodes coordinates - *Double* type with the size of 8 bytes. Then, to store the described arrays we need the following amount of memory:

$$N(W+2L+d)\cdot 8 + n\cdot E\cdot 4 = 5\cdot 105\cdot(500+2\cdot 2+2)\cdot 8+ 3\cdot 106\cdot 4 =$$
$$= 2024\cdot 106B \approx 1,89 \text{ GB.}$$

Comparing of computational complexities of two and three dimensional problems

Using the equations obtained from previous sections, we will conduct a comparison of computational complexities for two and three dimensional problems.

For illustrative comparison of complexities consider cubic body (Fig. 3). This will simplify our calculations, but will clearly illustrate the complexity of the transition to three-dimensional problem using Gaussian elimination. Body divided into a uniform grid with h nodes per each edge. Denote the number of nodes needed to solve two dimensional problems through N_{2D} and bandwidth through W_{2D}. For three dimensional problems these values denote respectively N_{3D} and W_{3D}, each of h times larger than its two-dimensional analogue (9),(10).

$$N_{3D} = hN_{2D} \tag{9}$$

$$W_{3D} = hW_{2D} \tag{10}$$

By substituting of obtained number of nodes and bandwidth for three-dimensional problem to (5) and dividing to complexity of two dimensional problem (5) we obtain an expression that shows how many times the three-dimensional problem is more complex of its two dimensional analogue (11).

$$O(N_{3D}W_{3D}^2)/O(N_{2D}W_{2D}^2) =$$
$$= O(hN_{2D}(hW_{2D})^2)/O(N_{2D}W_{2D}^2) \approx h^3 \tag{11}$$

Now try to show how increased complexity of calculations in the solution of three dimensional problems, in comparison of two dimensional. For example, we consider square area. Uniform mesh is constructed so that every edge accounts 100 nodes.

Then in transition to three dimensional problem which describes the cube, according to (11) computational complexity will increase in 100^3 = 1 million times. Even if such a two dimensional problem will be calculated in 1

second, the three dimensional solution takes about 12 days.
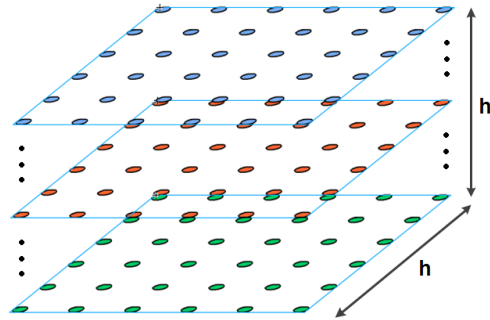
Fig. 3. Nodes location for three dimensional cubic body

Now conduct an approximate evaluation of machine memory using for example of a cubic body. According to (9), (10) the number nodes and bandwidth increase in the matrix in h times. In this evaluation we do not take into account the expressions of lower orders, so by substituting (9), (10) into (6) and dividing by (6) we obtain an approximate evaluation of increasing of memory using in the transition to three dimensional problems:

$$N_{3D}(W_{3D} + 2L)/N_{2D}(W_{2D} + 2L)) =$$
$$= hN_{2D}(hW_{2D} + 2L)/(N_{2D}(W_{2D} + 2L)) \approx h^2 \tag{12}$$

For example described above, obtained value shows that the memory usage will grow in almost 10 000 times. So even if the solution of two dimensional problem used only about 8 MB of memory, now this number will reach 80 GB which are not available for modern personal computers.

Perform an approximate evaluation of what size of three-dimensional cubic body problem our program can solve. Take the time limit in 10 hours. In calculating we based in the results from Table I from the first row. They obtained for a square body described by uniform grid on each side of which $h_{2D} = 501$ nodes. Number of nodes in the grid $N_{2D} = h_{2D}^2$, bandwidth of conductivity matrix $W_{2D} = h_{2D} +1$. This problem was solved in $T_{2D} = 536.42$ seconds. For the three-dimensional grid $N_{3D} = h_{3D}^3$, $W_{2D} = h_{3D}^2$. Now use evaluation of complexity (5) to determine how many nodes can be on edge of three-dimensional grid (Fig. 3) the solution of the problem lasted for 10 hours:

$$N_{3D}W_{3D}^2/T_{3D} = N_{2D}W_{2D}^2/T_{2D}$$
$$h_{3D}^7/T_{3D} = h_{2D}^4/T_{2D}$$
$$h_{3D}^7 = h_{2D}^4 T_{3D}/T_{2D}$$
$$h_{3D} = \sqrt[7]{h_{2D}^4 T_{3D}/T_{2D}} = \sqrt[7]{502^4 \cdot 36000/536} \approx 63$$

If the number of nodes is increased only by one to 64, the solution time will increase by 18 minutes.

The results show that software implementation of FEM is still possible to use Gaussian elimination at solving of two dimensional problems. But this method is unacceptable

costly for solving of the three-dimensional problems with large amount of nodes. Because the number of equations in such problems is increasing rapidly. The complexity of the cubic Gauss entire task complexity grows very rapidly, making this method unsuitable for large problems.

V. CONCLUSION

On the basis of analysis of asymptotic complexity of algorithm, it is possible to determine its critical places that have the greatest impact on performance. For the considered example the subroutine solving system of equations is proper. When input data is huge, the complexity of the whole problem is close to its complexity. Gaussian elimination can be used for systems with thousands of equations and unknowns, but when their amount reaches several million, the cost of solution becomes too large. In such cases the special iterative methods are used. Analysis of such methods is more difficult because their work time depends on the needed accuracy of the solution.

Number of nodes (N) appears in all expressions of algorithm complexity, both computational and of memory usage, which indicates the extreme importance of careful preparation of input data to get the most simplified model. The factor of the obtained complexity, which depends on the bandwidth of the matrix, grows the fastest. So, when preparing a finite element mesh, one has to pay close attention to the numbering of nodes in order to achieve as small as possible bandwidth.

REFERENCES

[1] K. Kurzydlowski, M. Lobur, I. Farmaga, O. Matviykiv. Data Processing Method for Determination Thermophysical Parameters of Composite Materials // IEEE MEMSTECH'2010. – Polyana, 2010. – PP. 264-266.

[2] I. Farmaga, P. Shmigelskyi, P. Spiewak, L. Ciupinski. Evaluation of Computational Complexity of Finite Element Analysis // IEEE CADSM'2011. – Polyana, 2011. – PP. 213 - 214.

[3] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to Algorithms, Second Edition. MIT Press and McGraw-Hill, 2001. Section 3.1: Asymptotic notation, PP. 41–50.

[4] Larry J. Segerlind. Applied Finite Element Analysis. Second Edition. – John Wiley and Sons, 1984.

Petro Shmigelskyi was born in Drohobych, Ukraine, Lviv reg., in August 19 1988. In 2010 got Master's degree of computer science at Lviv Polytechnic National Univercity, Ukraine.

He starts his career in computer development in 2007 in Lvov. At 2011 become PhD student at Lviv Polytechnic National University at CAD system department. The field of study is mathematical models for modeling of thermal processing in nanocomposites.

Publications: I. Farmaga, P. Shmigelskyi, P. Spiewak, L. Ciupinski. Evaluation of Computational Complexity of Finite Element Analysis // IEEE CADSM'2011. – Polyana, 2011. – Pp. 213 – 214; Farmaha, U. Marikutsa, P. Shmigelskyi. Solving of heat transfer problem of composite materials by finite element method. XVII Polish - Ukrainian Conference on "CAD in Machinery Design - Implementation and Educational Problems". – Lviv: Publishing House Vezha&Co. 2010.- Pp. 124 – 125; Bilal Radi A'Ggel Al-Zabi, Serhiy Tkatchenko, Petro Shmigelskyi. Solving of Typification Problem by Selection of Isomorphic Subgraphs //IEEE MEMSTECH'2010.- Polyana-Svalyava, UKRAINE: Publishing House Vezha&Co. 2010.- Pp.111-112.

Variants of Topology Editing Strategy in the Subsystem of Printed Circuit Boards Manufacturability Improvement

Roman Panchak, Konstantyn Kolesnyk, Marian Lobur

Abstract — **This paper focuses on the variants of printed circuit boards topology editing strategies implemented in the subsystem of automatic printed circuit boards topology editing. Depending on the requirements for printed circuit board topology, a subsystem user can create variants of editing strategies in order to minimize the amount of the technologically justified places with a minimum clearance between the elements of the topology.**

Index Terms — **printed circuit board topology, printed circuit board manufacturability.**

I. INTRODUCTION

The characteristic of topology of modern printed circuits board (PCB) is usages of diverse electronic components with conclusions fulfilled in miscellaneous systems of measurement (metric and inch) and usage at implementation of technological places of these units of a fair quantity miscellaneous under the shape and sizes of types of bonding contact pads. The modern technologies of making of PCB allow successfully to realize explorers in relation to a small width (0,075-0,15)mm. The programs of automatic trace [1-3] routine creations of the strategies of tracing, in which one the diverse criteria will be used. Traditional criteria for modern tracers is forming of dropwise form of blivets from the side of connecting to them of explorers, narrowing of wide explorers at connected to the blivets, straightening of explorers with the purpose of minimization of number of bends of explorers, round explorers in the. An attempt with the purpose of compression of topology to

Roman Panchak, lecturer, CAD Department, Lviv Polytechnic National University panchak@polynet.lviv.ua (CAD / CAM Department, Lviv Polytechnic National University, 12 S. Bandery Str., Lviv, 79013, UKRAINE, panchak@polynet.lviv.ua)

Konstantyn Kolesnyk, associate professor, CAD Department, Lviv Polytechnic National University kolesnyk@polynet.lviv.ua (CAD / CAM Department, Lviv Polytechnic National University, 12 S. Bandery Str., Lviv, 79013, UKRAINE, kolesnyk@polynet.lviv.ua)

Marian Lobur, student, CAD Department, Lviv Polytechnic National University loburm@yahoo.com CAD / CAM Department, Lviv Polytechnic National University, 12 S. Bandery Str., Lviv, 79013, UKRAINE, loburm@yahoo.com)

set minimum possible width of explorers for this class of PCB, generates after realization of topology the necessity of its editing with the purpose of diminishing of amount technologically unjustified bottlenecks. This procedure in modern systems of projection of topology [1]-[3] partly decides by the hand editing or by the use of certain iteration procedures in the interactive mode. For improvement of manufacturability of a figure on the factories, which one are engaged in serial manufacture PCB, on the stages of technological preparation of production will use some specialized systems [4],[5] Nevertheless it is necessary to recognize, that the editing of topology without participation of its developer sometimes loss results of capacity of PCB. Especially often it happens for PCB, on which one the topology will be realized, in which one the analog-digital signals on relation high measure frequencies (50-100) MHz and above are treated, and also it is necessary strictly to maintain topology with low levels of high frequency analog signals, for handling which one of coordinate of a feature placement and charting of explorers in strict correspondence with recommendations of firms of manufacturers electronic component.

It should be noted that for today the known system which decided an analogical task for the topologies of PCBS with substantial limits on types and amount of width of explorers, and also shape and sizes of bonding contact pads. For the indicated system essential limitation was step of a grid chart of topology PSB, besides the system operated under DOS, which became not actual today [6].

The subsystem of the automatic editing of topology of PCB, which one will be used after completion of development of topology and will be used for minimization of an amount of the technologically justified „narrow" places. An amount of widths of explorers, and also types and shapes of bonding contact pads, which one are treated by a system, is practically unreserved. The step of planning of a grid arbitrary. The subsystem will be used in a CAD system „Electron" has a library of translators for the transmission of topology from a few systems of planning.

As the stage of printed circuit board (PCB) topology design in the current systems has been completed, the pre-production stage is on its way. At this stage within design systems the control programs, which form PCB layers reflectance and drill the holes, are produced.

In order to improve manufacturability of the PCB picture in the Electron computer-aided design system, the subsystem of PCB topology technological editing has been implemented [7]-[9].

After the topology has been included into the editing subsystem, automatic increase of the sizes of contact pads and widths of the conductors to the values that are technologically justified for a given PCB accuracy class can be seen in the first stage of the system operation under the relevant settings in the system database

The second stage deals with searching for a "bottleneck" (a place where the clearance between elements of the topology is not proper for the given PCB accuracy class), if such a "bottleneck" has appeared at all after the first stage.
In the third stage the elements of topology are edited, in order to eliminate the bottleneck.

In the fourth stage the PCB layers topology is formed in the format, required by users.

The experience of using PCB topology editing subsystem revealed the necessity for the development of various editing strategies for the elements of topology, depending on the requirements for the topology and taking into account the PCB accuracy class.

This paper considers the variants of PCB topology editing strategies implemented in the subsystem of technological processing.

II. THE REALIZED PROCEDURES OF AUTOMATIC EDITING OF TOPOLOGY

After translation of the got topology forming of its internal form, the database of project is created and built mathematical model the structure of which is presented in [7]. At construction of model the increase of width of an explorer and increase of diameter of a bonding contact pad (CP) is carried out to the size which is set in a database for this class of PCB.

During scanning model appear „narrow" in topology and the optimization procedures on handling topology in a following sequence are executed:

1) The procedure of a rectification of explorers will be realized at enlarged width of explorers and diameters CP.

2) The procedure of rounding of the found obstacle an explorer is carried out, without the change of width of explorer, if such possibility exists. The adjacent explorers in local area of editing can test also changes. If available space allows on PCB, they shift on magnitude of an admissible clearance without change of width, if available space in the area of editing not, the explorers are narrowed to magnitude of a value of minimum width in a local place in topology.

3) If rounding of explorer is impossible, is executed cutting of explorer in local area of bottleneck to the width, which one is admissible for PCB of the given class. The cutting of explorer can be carried out discretely on the size of cutting, which one is set by the user.

4) In a case not of observance of a clearance between an explorer and bonding contact pad even at execution cutting of explorer, the cutting bonding contact pad (CP). The cutting of CP can be carried out discretely on a size which is set by a user, or at once on a maximally possible size but to the size of warranty belt of CP for this class of PCB.

5) The cutting of the form and sizes of PCB can take place as at the decision of conflict type „ CP - explorer" so at a conflict „CP-CP".

Such strategy of the technological editing of topology of PCB allows sharply to decrease a narrow seating capacity, provides optimization of topology after the criterion of maximal reliability of node in exploitation and minimization of shortage in a mass production.

III. PCB TOPOLOGY EDITING STRATEGIES

According to the national standard, there are five accuracy classes of structural elements (conductors, contact pads, holes, etc.) and limit deviations, as well as minimum nominal sizes for the bottleneck of the structural elements. Taking into account different accuracy classes of PCBs, the following variants of editing strategies can be used.

Third class PCBs

In PCB topologies of this class relatively wide conductors (0,6 ÷ 0,3 mm) and contact pads with diameters 1,2 ÷ 1,5 mm are used; relatively unsaturated topologies are implemented. To perform technological transformations for such PCBs in the editing subsystem one should use a strategy, which contains procedures of deep rounding of conductors, rounding of conductors involving narrowing and contact pads cutting procedure.

Unsaturated PCBs of the fourth and fifth classes

In the topologies of such PCBs the conductors with a small width (0,2 ÷ 0,25 mm) are used; the diameter of contact pads is 0,8 ÷ 1,0 mm; components with a small lead pitch, chips in packages with planar leads, circles with the frequency of signals up to 0.5 GHz are used.

The topology of such PCBs is moderately saturated and the width of conductors can be increased. If the structural constraints are absent, it is allowed, when editing, to round the contact pads with the conductors without narrowing the conductors to the technologically justified PCBs for the given accuracy class. If it is impossible to round the contact pad with the conductor without narrowing the conductors, the conductor has to be narrowed, and if it is not enough to ensure that the clearance is proper, the contact pad has to be cut.

To perform technological transformations for such printed circuit boards, a strategy, which contains functions of conductors rounding, conductors and contact pads cutting, has to be used.

Saturated digital and digital analog PCBs of the fourth and fifth accuracy classes

A characteristic feature of the PCBs of this class is high saturation of topology with conductors with small width (0,1 ÷ 0,15 mm). Contact pads diameter is 0,5 ÷ 0,8 mm. Components with a small lead pitch, chips in packages with solder balls, circles with the frequency of signals more than 1 GHz are used.

Editing strategy of such PCBs is largely determined by frequency characteristics of signals that pass through the conductors. In recent years the usage of differential pairs (identical information transmission through two adjacent conductors on the PCB with the phase difference of 180 degrees) for digital high-frequency equipment design in the PCB topology has considerably increased. Installation of conductors which transmit such signals to PCB imposes certain structural constraints on the topology elements of both the conductors, which transmit signals of differential pairs, and adjacent elements of the topology. Such circles are marked in the subsystem as fixed, which automatically means no possibility of editing at all.

Every day the leading firms-developers impose more and more strict requirements to the topology of the conductors that implement specific circles and parameters of the conductors (width, length) for the chips. When the possibility and parameters of such conductors are changed, the characteristics of signals are changed too, and sometimes PCB may become unworkable.

Taking into account frequency and structural constraints on the topology of conductors for such PCBs in the topology editing subsystem the strategy of cutting the contact pads is used.

In the editing subsystem user can also optionally create mixed topology editing strategies depending on the technological needs of the PCBs manufacturer.

The fact that there are a few variants of strategies of technological editing of PCB topologies allows to drastically reduce the number of bottlenecks, provides topology optimization by the criterion of maximum reliability of the node in operation and minimize rejects in serial production.

IV. RESULTS

The developed subsystem of technological editing of PCB topology is being used as a part of the Electron CADS at the Electron OJSC in Lviv. Figure 1 shows the photo of the fragment of PCB topology before and after technological editing with different variants of the technological editing strategy.
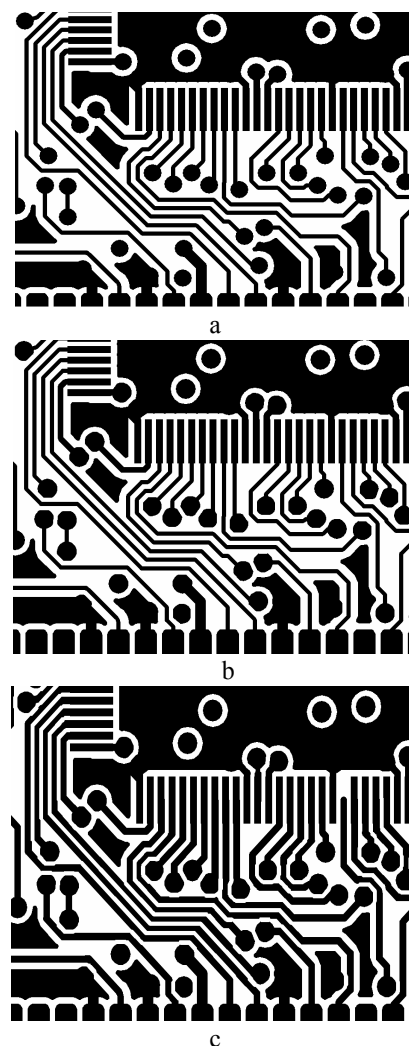
Fig. 1. The photos of the fragment of PCB topology:
a – topology before editing; b – contact pads cutting;
c – conductors and contact pads cutting

On Fig.2 the resulted picture of fragment of topology of DP is after treatment of the technological editing a subsystem. The system is exploited on a computer with the following configuration:

– Processor of AMD AthlonX2 5600+ (clock rate of a core 2,81GHz);

– RAM Patriot of 2x1Gb 6400 (800MHz);

– Hard disk of Samsung 320 Gb SATA2 16Mb of Cash;

– System board of Asus M2N-E nForce 570 Ultra;

– Descriptions of topology of PCB:

– A file size of description of topology is 72347 byte

– Amount of graphics primitives of topology – 12476

Expenses of processor time:

– Translation of file of topology in an internal form – 370 ms;

– Construction of mathematical model – 2485 ms;

– Editing of topology– 12796 ms;

– Saving of file – 267 ms;
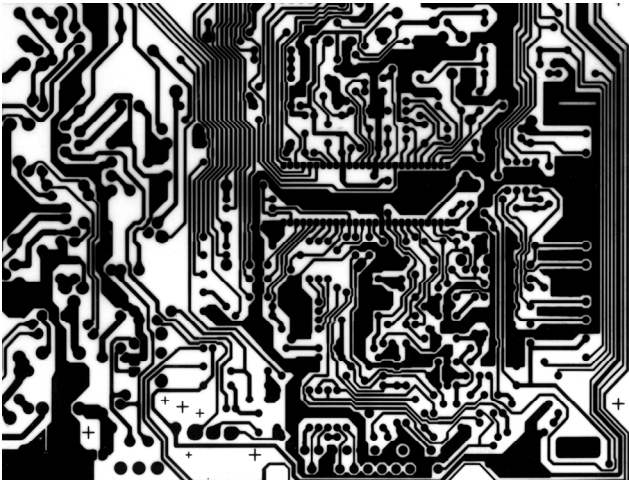
Fig.2. Picture to the fragment of topology of a PCB after handling by the subsystem of the technological editing of topology

IV. CONCLUSION

The subsystem of technological editing of PCB topology allows effective editing of topology elements using different strategies providing high manufacturability.

REFERENCES

[1]. www.cadence.com/product/pcb/pades/default.aspx
[2]. Altium Designer Schematic Capture and PCB Editing Training, 2006 – Altium Limited-248h
[3]. .www.mentor.com/products/pcb-system-design
[4]. www.frontline-pcb.com/category/Genesis_Overview
[5]. www.downstreamtech.com/cam350.html
[6]. Tetelbaum A., Byla U.N. Syntactic hike to transformation topologies of PCB// Automation designing in electronics: Resp.mezhved.nauch.-tekhn.sb. 1993., Is. 47.-p.41-50.
[7].Lobur M.V., Panchak R.T. Structure of mathematical model for the subsystem of the automatic editing of topology of PCBS. Announcer of the National university "Lviv polytechnic" № 651 the "Computer systems of planning. A theory and practice" Lviv, 2009, p. 84-87.
[8]. R. Panchak, O. Frider, D. Poluektov. Quadree and associative relationship based numerical scheme for automatic printed-circuit pattern editing subsystem. Proceedings of the V International Conference MEMSTECH'2009 "Perspective Technologies and Methods in Mems Design 2009,22-26 April 2009, Lviv-Polyana, p.130-133.
[9].R.Panchak, K.Kolesnik.Subsystem of Technological Editing of Topology of Plated Crcuits. Proceedings of the VI International Conference MEMSTECH'2010 "Perspective Technologies and Methods in Mems Design 2010,20-23 April 2010, Lviv-Polyana, p. 121-122.

Noise Reducing in Speech Signals Using Wavelet Technology

Yuriy Romanyshyn, Victor Tkachenko

Abstract – **In this paper the features of reducing of background noise in speech signals using discrete wavelet transforms with different wavelet bases, the analysis of choosing of different wavelet bases and decomposition levels of the signal are considered.**

Index Terms – **speech signal, discrete wavelet transform, noise, wavelet bases.**

I. INTRODUCTION

THE process of recording speech signal is often accompanied by the variety of acoustic noise. Their occurrence may be associated both with poor quality of equipment and with the presence of external noise sources. For using any method of recognition of speech signals it is important the reduction of noise, because their presence can severely affect the quality of recognition. The main directions of solving this problem are spectral methods and methods based on orthogonal discrete wavelet transforms. Due to the fact that the methods of wavelet transforms are more general compared with the spectral ones and there is quite a wide selection of used wavelet bases, the features of wavelet technology for noise reducing in speech signals are considered below.

Using the wavelet transforms for speech signal processing, including for the problem of reducing noise has not only purely mathematical basis, but the biophysical one also. Based on experimental data and analysis of the signal processing it can be substantiated that the man hearing, at least during the initial stage of processing of audio signals, implements the transform, that is equivalent to some wavelet transform [1].

Primary processing of acoustic information is carried out in the inner ear ("cochlea"). Based on experiments and the following numerical simulation it was found that the response at harmonic signal $u_\omega(t) = e^{j\omega t}$ depends not only on the frequency of the signal, but also on the geometric coordinate along the cochlea. This dependence is expressed by the following relation [1]:

$$v_\omega(t, y) = e^{j\omega t}\varphi(\omega, y), \qquad (1)$$

where $\varphi(\omega, y)$ - function that depends on the frequency ω and coordinate y.

Thus, the spectral selectivity of man hearing along the coordinate is appeared, that can be interpreted as spectral characteristic of auditory channel. In the first approximation for frequencies over 500 Hz this characteristic can be approximated by the expression [1]:

$$\varphi(\omega, y) = \varphi\left(\frac{y}{y_0} - \ln\frac{\omega}{\omega_0}\right), \qquad (2)$$

where y_0 and ω_0 - normalizing coefficients.

As a result for an arbitrary signal $u_1(t)$ output signal $u_2(t, y)$ at moment t with coordinate y is determined by the expression:

$$u_2(t, y) = \omega_0 a \int_{-\infty}^{\infty} u_1(\tau)\psi(\omega_0 a(\tau - t))d\tau, \qquad (3)$$

where $a = \exp\left(\frac{y}{y_0}\right)$; ψ – some function, which depends on function φ.

This expression, up to a multiplier, corresponds to continuous wavelet transform with scale $\dfrac{1}{\omega_0 a}$ and time shift t.

From the computational point of view the most widespread practical application has discrete wavelet transform (DWT) as a major alternative to discrete Fourier transform. DWT is widely used in problems of digital signal processing, including processing of speech signals. Therefore, for noise reducing in speech signals the methods based on wavelet technology are used.

The purpose of this work is researching and developing the methods of noise reducing in speech signals based on wavelet technology.

II. Wavelet -technology in speech signal processing

Wavelet technology at various stages of processing speech signals - noise reducing, segmentation, recognition is used.

Algorithm for noise reducing (which basically was already a classic) consists of the following steps:

1) discrete wavelet transform the signal to noise;

2) threshold processing of the wavelet coefficients (with possible adaptation);

3) reproduction signal by inverse wavelet transform.

In [2] the application of wavelet transform for task segmentation of speech signals and to noise reducing in them is considered. Wavelet transform shows the signal in scale-(frequency) time domain:

$$f(t) = \sum_k \lambda_i(k)\varphi_{ik}(t) + \sum_k \sum_{j=i}^{\infty} \gamma_j(k)\psi_{jk}(t), \quad (9)$$

where $\lambda_i(k)$ – approximation coefficients; $\gamma_j(k)$ – detail coefficients; $\varphi_{ik}(t)$ – scaling function; $\psi_{jk}(t)$ – wavelet function; k – the scale; i, j – shifts.

In the speech signal on low-noise signal / noise ratio 32 dB imposed. Noise by the sounds of machinery was created. To estimate the noise level used a fragment of the speech signal with missing information component, which noise component introduced. Due to the discrete wavelet transform to noise reducing S / N ratio increased to 37 dB when using the coefficients of detail only the first level of decomposition. To experimentally Board as the best for the speech signal (sampling frequency 11 025 Hz) wavelet basis functions Daubechies 10th order was selected.

In [3] a method of improving the speech signal using wavelet transform-based operator of energy is considered. In this and some other works as a noise signal simulated additive gauss white noise is used.

In [4] to improve speech signals using the bionic wavelet transform and recurrent neural network is considered. This method can be represented by two parts. The first step is the realization of bionic wavelet transform, the second - the using of recurrent neural network to find a set of wavelet coefficients, which by noise reducing are removed.

Two methods for noise reducing from speech signal in [5] proposed. They are based on empirical mode decomposition. Different versions of the application of wavelet technology in speech signals to noise reducing in [6], [7], [8], [9] are considered. This confirms their wide application in problems of noise reducing in creating systems of recognition of speech signals.

Application of wavelet technology, combined with spectral and cepstral coefficients in automatic speech recognition in [10] are illustrated.

III. Wavelet-transform of signal in orthogonal basis

Discrete wavelet transform of signal $S[i]$ ($i = \overline{1, m}$, m – number of signal counts) using the scaling function $\varphi(t)$, that at each scale 2^j satisfies condition orthonormalization to shifts in time to $2^{-j}k$ and $2^{-j}m$ ($k, m \in Z$) carried out:

$$\int_{-\infty}^{\infty} 2^{j/2}\varphi(2^j t - k)2^{j/2}\varphi(2^j t - m)dt = \delta_{km},$$

where δ_{km} – Kronecker symbol, Z- set of integers.

In addition, the function $\varphi(t)$ satisfies the normalization condition:

$$\int_{-\infty}^{\infty} \varphi(t)dt = 1.$$

With the scaling function $\varphi(t)$ bound wave function $\psi(t)$, discrete samples which are determined by function samples $\varphi(t)$ ratio:

$$\varphi[i] = (-1)^i \psi[n+1-i]; \quad i = \overline{1, n},$$

where the number of counts n defined by functions $\varphi(t)$ and $\psi(t)$.

Discrete counts $\widetilde{\varphi}[i] = \varphi[n+1-i]$ and $\widetilde{\psi}[i] = \psi[n+1-i]$ is the discrete impulse response digital filters respectively lower and upper frequencies. Reliable signal for a given discrete functions $\varphi[i]$ and $\psi[i]$ carried out in accordance with the scheme shown in Fig. 1 [1].
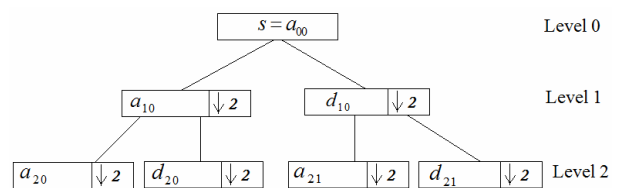
Fig. 1. Binary tree decomposition of multilevel signal

The signal sequence into a number of levels can be decomposed. At each level signal from a pool of sublevels, which correspond to the coefficients of approximation a_{jr} and detail coefficients d_{jr} (j – level number; r – number of pairs of sublevels) is generated. Each of the sublevels into two sub at a lower level can be dissected. Coefficients a_{jr} resulting digital signal filtering at the highest level of

low-pass filter with impulse response $\widetilde{\varphi}[i]$, and coefficients d_{jr} – filter high-pass characteristic of $\widetilde{\psi}[i]$ followed by decimation ($\downarrow 2$). These coefficients are determined by the recurrence relations [11]:

$$a_{j+1,2r}[k] = \sqrt{2} \sum_{i=\max(1;2k+1-n)}^{\min(n;2k)} a_{jr}[i]\varphi[i+n-2k];$$

$$d_{j+1,2r}[k] = \sqrt{2} \sum_{i=\max(1;2k+1-n)}^{\min(n;2k)} a_{jr}[i]\psi[i+n-2k];$$

$$a_{j+1,2r+1}[k] = \sqrt{2} \sum_{i=\max(1;2k+1-n)}^{\min(n;2k)} d_{jr}[i]\varphi[i+n-2k];$$

$$d_{j+1,2r+1}[k] = \sqrt{2} \sum_{i=\max(1;2k+1-n)}^{\min(n;2k)} d_{jr}[i]\psi[i+n-2k];$$

$$j = 0; \; r = 0; \; j = 1,2,...; \; r = 0,1,...,2^{j-1}-1.$$

Formula for reproduction coefficients and detail coefficients at the higher level of lower-level have the form [12]:

$$a_{jr}[2k-1] = \sqrt{2} \sum_{i=k}^{k+n/2-1} (a_{j+1,2r}[i]\varphi[n+1-2i] +$$

$$+ d_{j+1,2r}[i]\psi[n+1-2i]);$$

$$a_{jr}[2k] = \sqrt{2} \sum_{i=k}^{k+n/2-1} (a_{j+1,2r}[i]\varphi[n+2-2i] +$$

$$+ d_{j+1,2r}[i]\psi[n+2-2i]);$$

$$d_{jr}[2k-1] = \sqrt{2} \sum_{i=k}^{k+n/2-1} (a_{j+1,2r+1}[i]\varphi[n+1-2i] +$$

$$+ d_{j+1,2r+1}[i]\psi[n+1-2i]);$$

$$d_{jr}[2k] = \sqrt{2} \sum_{i=k}^{k+n/2-1} (a_{j+1,2r+1}[i]\varphi[n+2-2i] +$$

$$+ d_{j+1,2r+1}[i]\psi[n+2-2i]);$$

$$k = \overline{1, m_j/2}.$$

Multilevel signal decomposition $s(t)$ in orthogonal wavelet basis (wavelet series) has the form [19]:

$$s(t) = \sum_{j=-\infty}^{\infty} v_j \varphi_j(t) + \sum_{i=0}^{\infty} \sum_{j=-\infty}^{\infty} w_j^{(i)} \psi_j^{(i)}(t),$$

where $\varphi_j(t)$ - shifted scaling functions for the initial decomposition; $\psi_j^{(i)}(t)$ – appropriate scaled (on i-th level) and shifted wavelet function; v_j and $w_j^{(i)}$ – expansion coefficients.

For digital signal $s[n]$ ($n = \overline{1,m}$, m – number of signal counts) equivalent wavelet series is discrete wavelet

transform, in which is a multilevel signal decomposition with the calculation of each i-th level decomposition approximation coefficients $a_j^{(i)}$ by low-pass filter coefficients and detail $d_j^{(i)}$ using the High Pass Filter.

To calculate the coefficients of approximation and detail signals and playback schedules used for their respective functions DWT and IDWT mathematical package MATLAB [2].

IV. Noise reducing in speech signals using wavelet transforms

For the computational experiments speech signals from the database on the Internet [13], which were files with a record of different words and different speakers, were used. Noise signal components formed separately track several types of noise, which formed the basis of linguistic signals with additive noise for each reference signal various kinds of noise was in turn added.

The essence of the process of noise reducing is to schedule the speech signal on several levels, finding the approximation coefficients at the last level of detail coefficients at all levels, elimination (equating to zero) coefficients of detail levels on the scale that can meet the revised noise (usually those detail coefficients of wavelet decomposition module which is smaller than some specified threshold, and the required level and thresholds established experimentally). At the final stage of purification voice signal by inverse wavelet transform was synthesized. The effectiveness of noise reducing energy density by the difference signal, which was obtained after purification of the input signal with added noise determined and the obtained spectra and their difference in their wavelet coefficients was compared.
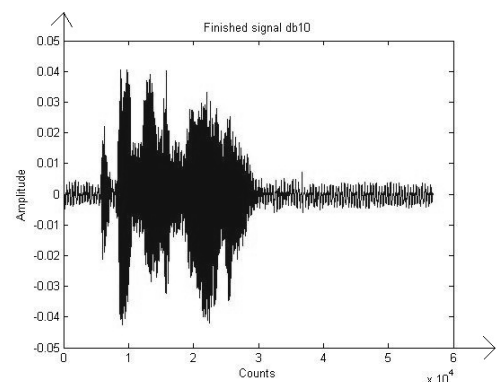
Fig. 2. The resulting signal after noise reducing by db10

Computational experiments for different signals, noises, different wavelet bases, using different levels of decomposition were conducted. In Fig. 2 an example of one of result - the Ukrainian word "married" where the added noise signal (Fig. 3) was reduced is presented.
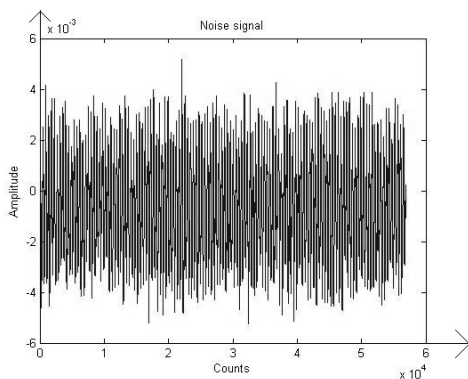
Fig 3. Interference signal

In particular, wavelet Daubechies bases order 2, 4, 6, 8, 10 was used. With their application signals cleared was received, since this was the best result that is confirmed by the obtained ratios of signal / noise ratio. Namely, the level of signal / noise ratio in noisy signals in decibels was:

TABLE I
PREDICTED SOLUTION TIME

	Db10	Db 8	Db 6	Db 4	Db 2
Word1	26.55	26.52	26.53	26.53	26.51
Word 2	50.66	50.63	50.63	50.64	50.64
Word 3	51.07	51.04	51.05	51.06	51.05
Word 4	62.67	62.64	62.65	62.66	62.66

Following algorithm procedures for processing signals (from noise to clean signal) is proposed:

1. Input signals (standard and noise).
2. Determination of the maximum level of noise signal and set the threshold based on it.
3. Adding noise signal to the reference signal.
4. Determination of the ratio signal / noise in the noised signal.
5. Schedule noisy signal obtained by Daubechies wavelet bases (for bases in turn 2, 4, 6, 8, 10).
6. Removing noise component from the signal.
7. Restoration of signal using the inverse wavelet transform.
8. Determination of the ratio signal / noise in the signal cleared.
9. Output of the results.

IV. CONCLUSION

During the experiments we used wavelet bases 2, 4, 6, 8, 10 of Daubechies family and the method validation results using the signal / noise ratio obtained in the process of cleaning and noise signals was proposed. It was determined that the best results in solving the problem is the use of wavelet db10.

REFERENCES

[1]. Daubechies I. Ten Lectures on Wavelets // CBMS-NSF Series in Applied Mathematics. Philadelphia: SIAM Publications, 1992. 357 p.
[2] G.Dobrushkin, V.Danilov. Application of wavelet transform for noise removal and segmentation of speech signals / / Scientific news "KPI". 2010 / 2. S. 34-42.
[3] M. Bahoura, J. Rouat, Wavelet Speech Enhancement based on the Teager Energy Operator, Signal Processing Letters, vol.8, Issue: 1, pp.10-12, 2001.
[4] M. Talbi, L. Salhi, W. Barkouti and A. Cherif, Speech Enhancement with Bionic Wavelet Transform and Recurrent Neural Network, 5th International Conference: Sciences of Electronic, Technologies of Information and Telecommunications SETIT 2009 March 22-26, 2009 – TUNISIA – 9 p.
[5] K. Khaldi, A.-O. Boudraa, A. Bouchikhi and M.T.-H. Alouane, Speech Enhancement via EMD, EURASIP Journal on Advances in Signal Processing, Volume 2008, Article ID 873204, 8 p.
[6] Q. Fu, E.A. Wan, A Novel Speech Enhancement system based on Wavelet Denoising, Center of Spoken Language Understanding, OGI School of Science and Engineering at OHSU, 9 p., February 14, 2003
[7] M. Bahoura and J. Rouat, "Denoising by Wavelet Transform: Application to Speech Enhancement". Canadian Acoustics, Vol. 28, No. 3, pp 158-159, 2000.
[8] Y. Ghanbari, M.R. Karami, S.Y. Mortazavi, A New Speech Enhancement System Based on the Adaptive Thresholding of Wavelet Packets, 13th ICEE2005, Vol. 1, Zanjan, Iran, May 10-12, 2005, 6 p.
[9] A.V. Lastochkin, V.Yu. Kobelev, The Denoising Method Based on the Wavelet Processing Adapted for Sharp Signals, DSPA-2000, 2 p.
[10] M.C.A. Korba, D. Messadeg, R. Djemili, H. Bourouba, Robust Speech Recognition Using Perceptual Wavelet Denoising and Mel-frequency Product Spectrum Cepstral Coefficient Features, Informatica 32 (2008), 283-288.
[11]. Yu Romanyshyn, W. Gudym. Compression of speech signal based on discrete wave transformations / Radioelectronics and Telecommunications. Bulletin of the National University "Lviv Polytechnic", № 428. - Lviv, 2001. - S. 22-27.
[12] A. Pereberin. About the systematization of wavelet transforms / / Computational Methods and Programming. - 2001. - T. 2. - S. 15-40.
[13] http://www.speech.com.ua/russian.html.

Victor Tkachenko was born in L'viv, Ukraine, in September 9 1986. In 2008 got Master's degree of computer science at Lviv Polytechnic National Univercity, Ukraine.
At 2008 become PhD student at Lviv Polytechnic National University at EMCAT department. The field of study is speech recognition task.
Publications: V.Tkachenko, Yu.Romanyshyn. Noise reducing in speech signals using wavelet technology // IEEE CADSM'2011. – Polyana, 2011. – P. 446; V. Pavlysh, Yu. Romanyshyn, V. Tkachenko. Software tools of construction, training and using of hidden Markov models in MATLAB system. Proceedings of the IXth International Conference CADSM'2009. - Lviv-Polyana: Publishing House of the Lviv Polytechnic National University, 2009. - P.125; V. Pavlysh, Yu. Romanyshyn, V. Tkachenko. Preliminary segmentation of speech signals for the tasks of their recognition. //IEEE MEMSTECH'2009. - Polyana, 2009. - P.144

System Supporting Planning and Management of Time and Cost of Projects Based on Java EE Platform

Szymon Kubicz, Przemysław Nowak, Michał Wojtera, Jarosław Komorowski, Bartosz Sakowicz

Abstract – **The aim of this article is to present a management supporting system which follows unique project management methodology. The article shows how to integrate different frameworks, libraries and technologies working on Java Enterprise Edition platform in order to create fully operable and very useful internet application.**

Keywords – **Java EE, JAVA, JSF, SPRING**

I. INTRODUCTION

In the era of advanced technologies and continuous rapid development of civilization, few things became extremely important: hard work and also good planning and coordination of that work.

Therefore over the past years began to appear more and more project management tools similar to the system described in this article [7,12]. The implementation methodology uses technologies based on Java EE platform, such as JSF or Spring. Thanks to them it was created functional website which is helpful for everyone involved in the project life cycle. With the interactive Gantt's graph, system allows intuitive scheduling and comfortable project management.

II. PROJECT MANAGEMENT

Project is a unique sequence of tasks undertaken with the aim achieves unique objectives within a specific timeframe [4]. The key features of the project are:
- Aim
- Finite duration
- Uniqueness
- Element of uncertainty and risk
- Distinct structural

Project management is striving to achieve specific aim, remaining within the prescribed time, cost and reaching at the beginning a complex of final product quality. The measure of success in project management is: range – means how many objectives succeeded, quality – are customers pleased, resources – did appear looses in team or deterioration in team relations. Relations between individual successes meters can be presented in graphical from using the so-called project management triangle (Fig.1) [5].
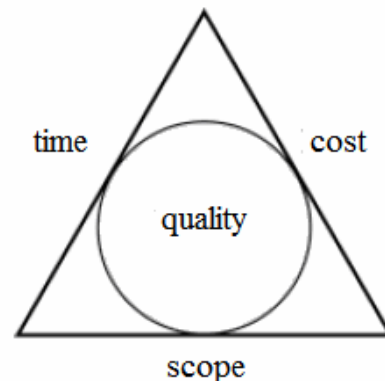
Fig. 1. Project Management Triangle [4]

III. TECHNOLOGIES USED IN APPLICATION

Applications based on Java Enterprise Editions, although they require more work and attention, they offer number of interesting features such as standard formation, scalability, portability. These features have convinced many companies which produce web-based software.

Presentation layer in described system was made with usage of Java ServerFaces Framework. JSF has many values, which meaningfully facilitates implementation of user interface, few of them are introduced below:
- predefined interface components,
- event driven programming model,
- model components, through developers can create their own components and reuse them in many projects,
- usage of MVC (Model View Controller) design pattern.

To implement a persistent layer Hibernate framework has been used, which is the one of the most popular tools served to object relational mapping. Additionally Spring framework was used, which provides support in all stages of application design. Moreover it allows for easy integration with specialized frameworks such as JSF and Hibernate.

III. SPRING SECURITY

Spring Security requires creation of database tables according to scheme introduced on Fig.2 [9-11].
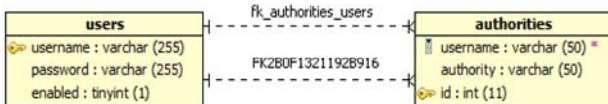
Fig. 2. Spring Security – database tables

In configuration file must be defined object responsible for access to the database. Than it is necessary to configure authentication-manager, which is responsible for authorization. It needs to be transmitted references to object authentication-provider, which is responsible for delivering to users, including their roles. In addition authentication-provider can be determined about the way of encoding passwords. Configuration of authentication-manager presents Fig.3.

```
<authentication-manager alias =
"authenticationManager">
     <authentication-provider>
       <password-encoder hash="md5"/>
       <jdbc-user-service data-source-ref =
"dataSourceSecurity"
     users-by-username-query="SELECT username,
password, enabled FROM users where username=?"/>
       </authentication-provider>
</authentication-manager>
```

Fig. 3. Spring Security – authentication-manager

Subsequently must be determined login page and access rights to specific resources.

IV. SPRING - HIBERNATE

Configuration Spring – Hibernate is limited to one configuration file. In described application the file is spring-context.xml. Other part of configuration has been moved to Java classes using annotation mechanism. Setting up the annotation was made possible by adding an entry in configuration file (Fig.4):

```
<context:annotation-config />
```

Fig. 4. Spring – Hibernate – enabling annotations mechanism

and determining package, in which Spring will search objects which contains annotations (Fig.5).

```
<context:component-scan base-package="com.thesis">
  <context:include-filter type="annotation"
    expression= "org.springframework.stereotype.
Repository"/>
</context:component-scan>
```

Fig. 5. Spring – Hibernate – component-scan.

Next step is to configure object containing bearings of database and determining how to access it (Fig. 6):

```
<bean id="hibernateDataSource"
class="org.apache.commons.dbcp.BasicDataSource"
destroy-method="close">
  <property name="driverClassName"
value="com.mysql.jdbc.Driver"/>
  <property name="password" value="szym"/>
  <property name="url"
value="jdbc:mysql://localhost/temp?characterEncoding
=UTF-8"/>
  <property name="username" value="root"/>
</bean>
```

Fig. 6. Connection with data base.

If the application uses Spring framewokr, and the role of deliverer of the Java Persistence API belongs to Hibernate then must be determine so-called vendor adapter object (Fig.7).

```
  <bean id="vendorAdapter"
     class="org.springframework.orm.jpa.vendor.
HibernateJpaVendorAdapter">
     <property name="showSql" value="false"/>
  </bean>
```

Fig. 7. Spring – Hibernate – vendorAdapter

The last step of configuration Hibernate using Spring is to determine object of session factory (SessionFactory). It is Hibernate object serving creation of session (objects of Session type), which in turn manages connection data.

Than it is necessary to creat DAO (Data Access Object), which will deliver uniform interface for communication between Java objects and database. In implementation of interface it is necessary to provide annotation which will give information about DAO class for framework (Fig.8).

```
     @Repository("projectDAO")
```

Fig. 8. Spring – Hibernate – annotation Repository

DAO class should also inherit from HibernateDAOSupport class. It is an object which makes available the whole set of methods for handling data access. Usage of HibernateDAOSupport allows programmer to ignore all problem related to transactions and sessions management. However, in order to work properly, to the HibernateDAOSupport has to be delivered session factory,

which was set up earlier. For this purpose it can be used Autowired annotation, which causes that SessionFactory object is 'injected' automatically (Fig.9).

```
@Autowired
public void init(SessionFactory sessionFactory){
    setSessionFactory(sessionFactory);
}
```
Fig. 9. Spring – Hibernate – injection of session factory to DAO class

With DAO object programmed it is possible to access the application in the easy way (Fig.10).

```
@ManagedBean("principalBean")
@Scope("session")
public class PrincipalBean {
    private ProjectDAO projectDAO = null;
    @Autowired
    public PrincipalBean(@Qualifier("projectDAO")
ProjectDAO project) {
        projectDAO = project;
        getPass();
        init();
        currentStock =
stockList.get(currentStockIndex);
        getProjectByPrincipal();
    }
}
```
Fig. 10. Spring – Hibernate – DAO object in use

This sample source code presents exemplary 'inject' of an object implementing interface ProjectDAO. Usage of reverse control design pattern, application can operate on the same interface in complete separation from specific implementation [6]. Object implementing ProjectDAO interface provides methods which allow for database operation. The database schema used in application is shown on Fig.11.
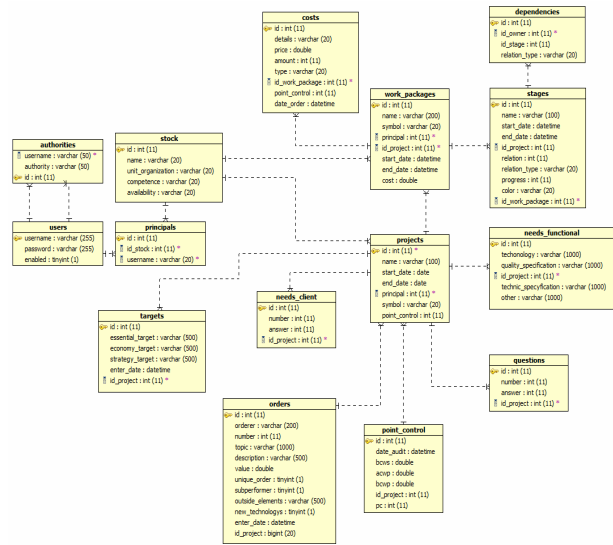
Fig. 11. Database schema

V. ANNOTATIONS

Programming annotations gives a lot of possibilities of including additional information directly in the source code. So far, it was not possible. Until annotations became available for Java programmers, all configuration has to be done in external XML files. For example, configuration of JSF beans have been done in the faces-config.xml and it looked as follows [1,8]:

```
<managed-bean>
    <managed-bean-name>principalBean</managed-
bean-name>
    <managed-bean-
class>com.thesis.principal.PrincipalBean</managed-
bean-class>
    <managed-bean-scope>session</managed-bean-
scope>
  </managed-bean>
```
Fig. 12. Traditional bean initialization in JSF

Due to annotations programmer can configure exactly the same features in application by adding designation directly in interesting class of source code (Fig.13).

```
@ManagedBean("principalBean")
@Scope("session")
public class PrincipalBean {
…
```
Fig. 13. Initialization JSF bean with annotation

Another example of convenient usage of annotations are POJO's classes used by Hibernate for object-relational mapping. It allows to get rid of enormous number of .hbm configuration files, and to locate directly all of configuration in proper classes.

VI. GANTT CHART

One of the key tools which described applications offers is interactive Gantt chart (Fig. 14).
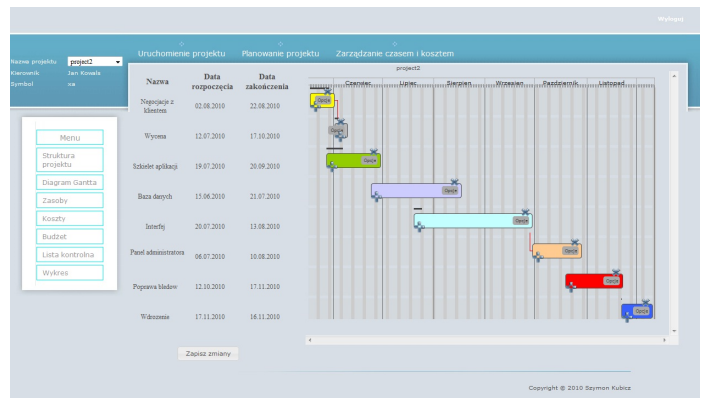
Fig. 14. Gantt Chart

The graph's engine is programmed due to jQuery library. The information needed to generate it are taken from database. The whole object, which represents the project, is transformed to a JSON format. Followed by corresponding field, announcement is retrieved by browser part of application.

VII. FUNCTIONALITY OF THE SYSTEM

The presented web-based system certainly can be useful for managers who want to organize and sort the projects which were undertaken by a company. It provides support for three main stages of project management:

- starting – classification of orders, establishment of a manager, setting objectives, customer needs and functional needs,
- planning – structuring and scheduling the project, creating budget, graphical representation of project costs
- management of time and cost – creation of control points, controlling the time and expenditures by using earned value method.

Additionally, due to security restrictions mechanism, all information are available only for authorized persons.

VIII. CONCLUSION

The described application was created in order to support project managers in their work. The proposed system is ready for use during common work with the project. Furthermore, it is easy and convenient to use. Gantt chart is an attractive graphical tool for manipulation of the project schedule.

The fact that the application was made by agile application frameworks such as Spring makes its implementation ease readable and ready for future enhancements. As a deployment environment, any Java EE compliant application server can be used (e.g. Tomcat).

The system can be also easy extended both in terms of its functionality (to ensure compliance with all agreed methodology) as well as in technical features
.

REFERENCES

[1] Eckel Bruce, Thinking In Java, Helion S.A., Gliwice 2006

[2] Geary David, Horstmann Cay S., Core JavaServer Faces, wydanie II, Helion S.A., Gliwice 2008

[3] Johnson Rod, Hoeller Huergen, Arendsen, Risberg Thomas, Sampaleanu Colin, Spring Framework – Profesjonalne tworzenie oprogramowania w JAVIE, Helion S.A., Gliwice 2006

[4] Mingus Nancy, Zarządzanie projektami, Helion S.A., Gliwice 2002

[5] William R. Duncan, A Guide To The Project Management Body Of Knowledge, PMI Standards Committee, Project Management Institute, PA 19082 USA.

[6] M. Zywno, B. Sakowicz, K. Dura, A. Napieralski "J2EE Design Patterns Applications" 12 th International Conference MIXDES 2005, Kraków, Poland, 23-25 June, pp. 627 - 630, vol. 1, ISBN 83-919289-9-3

[7] Wojtera M., Sakowicz B.: „Web Application for Project Management Based on Open Source Solutions", 13th International Conference Mixed Design of Integrated Circuits and Systems MIXDES 2006, 22-24 czerwca 2006, Gdynia, wyd. KMiTI, str. 797-800, ISBN 83-922632-9-1

[8] Karolina Czekalska, Bartosz Sakowicz, Jan Murlewski, Andrzej Napieralski: "Hotel Reservation System Based on the JavaServer Faces Technology", 9th International Conference Modern Problems of Radio Engineering, Telecommunications and Computer Science, TCSET'2008, 19-23 February 2008, Lviv-Slavsko, Ukraine, ISBN 978-966-553-678-9

[9] Szymon Gradka, Bartosz Sakowicz, Piotr Mazur, Andrzej Napieralski: "CRM system with behavioral scenarios based on Spring framework", 9th International Conference Modern Problems of Radio Engineering, Telecommunications and Computer Science, TCSET'2008, 19-23 February 2008, Lviv-Slavsko, Ukraine, ISBN 978-966-553-678-9

[10] Marcin Mela, Bartosz Sakowicz, Jakub Chlapinski: "Advertising Service Based on Spring Framework", 9th International Conference Modern Problems of Radio Engineering, Telecommunications and Computer Science, TCSET'2008, 19-23 February 2008, Lviv-Slavsko, Ukraine, ISBN 978-966-553-678-9

[11] PILICHOWSKI M., SAKOWICZ B., CHŁAPIŃSKI J.; "Real-time Auction Service Application Based on Frameworks Available for J2EE Platform", pp. 166-169, Proceedings of the Xth International Conference TCSET'2010, "Modern Problems of Radio Engineering, Telecommunications and Computer Science", Lviv-Slavsko, Ukraina, 23-27 February 2010, s.380, A4, wyd. Publishing House of Lviv Polytechnic National University 2010, ISBN 978-966-553-875-2

[12] Jamroz, A.; Zabierowski, W.; Napieralski, A.: "Work time management in a small company as example of usage the web technologies" CAD Systems in Microelectronics, 2009. CADSM 2009. 10th International Conference - The Experience of Designing and Application of; 2009, ISBN 978-966-2191-05-9

Main Strategies for Autonomous Robotic Controller Design

I. Paterega

Abstract— **This review gives an overall introduction to the artificial evolution mechanism. It presents the main strategies for robotic controller design. It gives a review of the pertinent literature, focusing on approaches that use neural networks, evolutionary computing, and fuzzy logic. Various applications of artificial evolution in robotics are surveyed and classified.**

Index Terms— **evolutionary algorithms, fuzzy logic, neural networks, robot navigation.**

I. INTRODUCTION

Early robots were nothing more than clever mechanical devices that performed simple pick-and-place operations. Nowadays robots are becoming more and more sophisticated and diversified so as to meet the ever-changing user requirements. The robots are developed to perform more precise industrial operations, such as welding, spray painting, and simple parts assembly.

However, such operations do not really require the robot to have intelligence and behave like human beings since the robots are simply programmed to perform a series of repetitive tasks. If anything interferes with the prespecified task, the robot cannot work properly anymore, since it is not capable of sensing its external environment and figuring out what to do independently.

Modern robots are required to carry out work in unstructured dynamic human environments. In the recent decades, the application of artificial evolution to autonomous mobile robots to enable them to adapt their behaviors to changes of the environments has attracted much attention. As a result, an infant research field called evolutionary robotics has been rapidly developed that is primarily concerned with the use of artificial evolution techniques for the automatic design of adaptive robots. As an innovative and effective solution to autonomous robot controller design, it can derive adaptive robotic controllers capable of elegantly dealing with continuous changes in unstructured environments in real time [1]. It has been shown in [2] that the robot behaviors could be achieved more effectively by using simpler and more robust evolutionary approaches than the traditional decomposition/integration approach.

Evolutionary robotics aims to develop a suitable control system of the robot through artificial evolution. Evolution and learning are two forms of biological adaptation that operate on different time scales. Evolution is capable of capturing slow environmental changes that might occur through several generations, whereas learning may produce adaptive changes in an individual during its lifetime. Recently, researchers have started using artificial evolution techniques, such as genetic algorithm (GA), fuzzy logic (FA) and learning technique, namely neural network (NN), to study the interaction between evolution and learning [3].

Evolutionary robotics deals with this interaction. In behavior-based robotics, a task is divided into a number of basic behaviors by the designer and each basic behavior is implemented in a separate layer of the robot control system. The control system is built up incrementally layer by layer and each layer is responsible for a single basic behavior. The coordination mechanism of basic behaviors is usually designed through a trial and error process and the behaviors are coordinated by a central mechanism. It is important to note that the number of layers increases with the complexity of the problem and for a very complex task, it may go beyond the capability of the designer to define all the layers, their interrelationships and dependencies. Hence, there is a need for a technique by which the robot is able to acquire new behaviors automatically depending on the situations of changing environment. Evolutionary robotics may provide a feasible solution to the abovementioned problem. In evolutionary robotics, the designer plays a passive role and the basic behaviors emerge automatically through evolution due to the interactions between the robot and its environment.

This review gives an overall introduction of the artificial evolution mechanism. It presents the main strategies for robotic controller design. Various applications of artificial evolution in robotics are surveyed and classified. Furthermore, in this review their specific merits and drawbacks in robotic controller design are discussed, as at present, there is little consensus among researchers as to the most appropriate artificial evolution approach for heterogeneous evolutionary systems.

Iurii I. Paterega is with CAD/CAM Department, Lviv Polytechnic National University, 12, S. Bandera Str., Lviv, 79013, UKRAINE. E-mail: paterega@mail.lviv.ua

II. EVOLUTION MECHANISMS

A robot is required to have intelligence and autonomous abilities when it works far from an operator and these are a large time delay or working in a world containing uncertainty. The robot collects or receives the necessary information concerning its external environment, and takes action in the environment. Both processes are usually designed by human operators, but ideally, the robot should perform the given task automatically without human assistance. Computational intelligence methods, including neural networks (NNs), fuzzy logic (FLs), evolutionary algorithms (EAs), reinforcement learning, expert systems and others, have been applied to realize intelligence in robotic systems.

To realize an advanced intelligent system, a synthesized algorithm of various techniques such as NN, FL, and EC is required. Each technique plays a specific role in intelligence features. There are no complete techniques for realizing all features of intelligence. Therefore, it is necessary to integrate and combine several techniques to compensate for the disadvantages of each technique. The main characteristics of NN are to classify or recognize patterns, and to adapt itself to dynamic environments by learning, but the mapping structure of NN is a black box and is incomprehensible. On the other hand, FL has been applied to represent human linguistic rules and classify numerical information into symbolic classes. It also has a reasonable structure for inference, which is composed of if-then rules as in human knowledge [4].

However, FL does not fundamentally have a learning mechanism. Fuzzy-neural networks have been developed to overcome these disadvantages. In general, the neural network part is used for learning, while the fuzzy logic part is used for representing knowledge. Learning capabilities such as incremental learning, the back-propagation method, and the delta rule based on error functions are used in essential changes. EC can also tune NN and FL. However, evolution can be defined as a resultant or accidental change, not a necessary change, since EC cannot predict or estimate the effect of the change. To summarize, an intelligent system can quickly adapt to a dynamic environment via NN and FL using the back-propagation method or the delta rule, and furthermore, the structure of an intelligent system can evolve globally via EC according to its objectives.

III. NEURAL NETWORKS

Many evolutionary approaches have been applied to the field of evolvable robotic controller design in the recent decades [5]-[7]. Some researchers used artificial Neural Networks (NN) as the basic building blocks for the control system due to their smooth search space. NNs can be envisaged as simple nodes connected together by directional interconnects along which signals flow. The nodes perform an input-output mapping that is usually some sort of sigmoid function.

An artificial NN is a collection of neurons connected by weighted links used to transmit signals. Input and output neurons exchange information with the external environment by receiving and broadcasting signals. In essence, a neural network can be regarded as a parallel computational control system since signals in it travel independently on weighted channels and neuron states can be updated in parallel. NN advantages include its learning and adaptation through efficient knowledge acquisition, domain free modeling, robustness to noise, and fault tolerance, etc. [8]. Also neural networks can easily exploit various forms of learning during life-time and this learning process may help and speed up the evolutionary process [9], [10]. Neural networks are resistant to noise that is massively present in robot/environment interactions. This fact also implies that the fitness landscape of neural networks is not very rugged because sharp changes of the network parameters do not normally imply big changes in the fitness level. On the contrary it has been shown that introducing noise in neural networks can have a beneficial effect on the course of the evolutionary process [11]. The primitive's components manipulated by the evolutionary process should be at the lowest level possible in order to avoid undesirable choices made by the human designer [12]. Synaptic weights and nodes are low level primitive components.

The behaviors that evolutionary robotics is concerned with at present are low-level behaviors, tightly coupled with the environment through simple, precise feedback loops. Neural networks are suitable for this kind of applications so that the predominant class of systems for generating adaptive behaviors adopts neural networks [13]. The same encoding schemes can be used independently of the specific autonomous robot navigation system since different types of functions can be achieved with the same type of network structure by varying the properties and parameters of simple processing used. Other adaptive processes such as supervised and unsupervised learning can also be incorporated into NN to speed up the evolution process.

NNs have been widely used in the evolutionary robotics due to the aforementioned merits. For instance, locomotion-control module based on recurrent neural networks has been studied by Beer and Gallagher [14] for an insect-like agent. Parisi, Nolfi, and Cecconi [15] developed back propagation neural networks for agents collecting food in a simple cellular world. Cliff, Harvey, and Husbands [12] have integrated the incremental evolution into arbitrary recurrent neural networks for robotic controller design. Floreano and Mondada [16] presented an evolution system of a discrete-time recurrent neural network to create an emergent homing behavior.

NN has also been used for Intelligent Autonomous Vehicles (IAV) design. The primary goal of IAV is related to the theory and applications of robotic systems capable of some degree of self-sufficiency. The focus is on the ability

to move and be self-sufficient in partially structured environments. IAV have many applications in a large variety of domains, from spatial exploration to handling material, and from military tasks to the handicapped help. The recent developments in autonomy requirements, intelligent components, multi-robot systems, and massively parallel computers have made the IAV very used in particular in planetary explorations, mine industry, and highways [17].

To reach their targets without collisions with possibly encountered obstacles, IAV must have the capability to achieve target localization and obstacle avoidance behaviors. More, current IAV requirements with regard to these behaviors are real-time, autonomy and intelligence. Thus, to acquire these behaviors while answering IAV requirements, IAV must be endowed with recognition, learning, decision-making, and action capabilities.

To achieve this goal, classical approaches rapidly have been replaced by current approaches in particular the Neural Networks (NN) based approaches. Indeed, the aim of NN is to bring the machine behavior near the human one in recognition, learning, decision-making, and action. In [17], a first current NN based navigation approaches in IAV, autonomy, and intelligence have been discussed.

However, neural networks also have certain drawbacks. For instance, a NN cannot explain its results explicitly and its training is usually time-consuming. Furthermore, the learning algorithm may not be able to guarantee the convergence to an optimal solution [8].

IV. EVOLUTIONARY ALGORITHMS

There are currently several flavors of evolutionary algorithms (EAs). Genetic Algorithms (GAs) [18] is the most commonly used one where genotypes typically are strings of binary. Genetic Programming (GP) [19] is an offshoot of GAs, where genotypes are normally computer programs. Other flavors such as Evolution Strategies (ES) are also used in evolutionary robotics (ER). Many concerns are shared among these approaches.

As a commonly used EA, GA has also been used in [10], [19] for generating robotic behaviors. Thompson [20] adopts the conventional GA as the training tool to derive the robot controllers in the hardware level. The encouraging experimental results justify the effectiveness of GA as a robust search algorithm even in hardware evolution.

Most applications nowadays use the orthodox GA, however, Species Adaptation GAs (SAGA) suggested by [21], [22] would be more suitable for certain robot evolution applications such as evolvable hardware based robotic evolutions. In SAGA, different structures are encoded with genotypes of different lengths, which offer a search space of open-ended dimensionality. Cyclic Genetic Algorithm (CGA) has also been introduced in [23] to evolve robotic controllers for cyclic behaviors. Also distributed genetic algorithms have been introduced into the evolutionary robotics field recently. For instance, in the spatially distributed GA, for each iteration a robot is randomly selected from a population distributed across a square grid. The robot is bred with one of its fittest neighbors and their offspring replaces one of the least fit neighbors such that the selection pressure keeps successful genes in the population. The distributed GA is usually robust and efficient in evolving capable robots. GA exhibits its advantages in deriving robust robotic behavior in conditions where large numbers of constraints and/or huge amounts of training data are required [24]. Furthermore, GA can be applied to a variety of research communities due to its gene representation. However, GA is computationally expensive [24]. Though GA is now widely used in the ER field, a variety of issues are still open in the GA-based ER.

For instance, the fitness function design is an important issue in GA-based evolution schemes [25]. The fitness function should present measurement of its ability to perform under all of the operating conditions. In fact, all these objectives can be fulfilled by setting an appropriate fitness function so as to derive the desired robotic performance exhibited during autonomous navigation. Therefore, the fitness function design needs to be investigated more carefully to make the robot evolve in a more effective way. Several experiments have also been performed where the robotic controllers were evolved through Genetic Programming (GP) [19], [26].

V. FUZZY LOGIC

Fuzzy logic provides a flexible means to model the nonlinear relationship between input information and control output [27]. It incorporates heuristic control knowledge in the form of if-then rules, and is a convenient alternative when the system to be controlled cannot be precisely modeled [28], [29]. They have also shown a good degree of robustness in face of large variability and uncertainty in the parameters.

These characteristics make fuzzy control particularly suited to the needs of autonomous robot navigation [30]. Fuzzy logic has remarkable features that are particularly attractive to the hard problems posed by autonomous robot navigation. It allows us to model uncertainty and imprecision, to build robust controllers based on the heuristic and qualitative models, and to combine symbolic reasoning and numeric computation. Thus, fuzzy logic is an effective tool to represent real world environments. In evolutionary robotics, fuzzy logic has been used to design sensor interpretation systems since it is good at describing uncertain and imprecise information.

All the specific methods have their own strengths and drawbacks. Actually they are deeply interconnected and in many applications some of them have been combined together to derive the desired robotic controller in the most effective and efficient manner. For instance, Fuzzygenetic system [31] is a typical evolution mechanism in evolving adaptive robot controller. Arsene and Zalzala [32] controlled the autonomous robots by using fuzzy logic controllers tuned by GA. Pratihar, Deb, and Ghosh [33]

used fuzzy-GA to find obstacle-free paths for a mobile robot. Driscoll and Peters II [34] implemented a robotic evolution platform supporting both GA and NN. Xiao, et al. [35] designed autonomous robotic controller using DNA coded GA for fuzzy logic optimization.

Fuzzy control has shown to be a very useful tool in the field of autonomous mobile robotics, characterized by a high uncertainty in the knowledge about the environment where a robot evolves. The design of a fuzzy controller is generally made using expert knowledge about the task to be controlled. Expert knowledge is applied in order to decide the number of linguistic labels for each variable, to tune the membership functions, to select the most adequate linguistic values for the consequents, and to define the rules in the fuzzy knowledge base. This process is tedious and highly time-consuming [36].

For this reason, automated learning techniques, such as evolutionary algorithms, have been employed for helping in some, or in all, of the tasks involved in the design process. In some of the approaches evolutionary algorithms are used just for tuning the membership functions. In others, the complete rule base is learned, starting from a hand designed data base (number and definition of the linguistic values and universe of discourse of the variables). But only in a few of them both the data base and the rule base are learned.

Mucientes, Moreno, Bugarin and Barro describe the learning of a fuzzy controller for the wall-following behavior in a mobile robot [36]. The learning methodology is characterized by three main points. First, learning has no restrictions neither in the number of membership functions, nor in their values. In the second place, the training set is composed of a set of examples uniformly distributed along the universe of discourse of the variables.

Fuzzy logic techniques are commonly used for navigation of different types of robot vehicles [38]. The popularity of fuzzy logic is based on the fact that it can cope with the uncertainty of the sensors and the environment really well. By using it, the robotic vehicles are able to move in known or unknown environments, using control laws that derive from a fuzzy rule base. This base is consisted from a set of predefined IF– THEN rules, which remains constant during the operation of the robot. These rules along with the membership functions of the fuzzy variables are usually designed ad hoc by human experts [37].

Several researchers have used fuzzy logic for the navigation of mobile robots. In [39], a layer goal oriented motion planning strategy using fuzzy logic controllers has been offered, which uses sub-goals in order to move in a specific target point. Another approach is presented in [40], where the authors offer a control system consisting of fuzzy behaviors for the control of an indoor mobile robot. All the behaviors are implemented as Mamdani fuzzy controllers, except for one which is implemented as adaptive neuro-fuzzy. In [41] a combined approach of fuzzy and electrostatic potential fields is presented that assures navigation and obstacle avoidance. The main drawback of these approaches is that the design of the fuzzy controllers relies mainly on the experience of the designer. In order to

overcome this problem several researchers have suggested tuning the fuzzy logic controller based on learning methods [42] and evolutionary algorithms [43–48], in an attempt to improve the performance and the behavior of the control procedure.

In [43], a fuzzy logic controller for a Khepera robot in a simulated environment evolved using a genetic algorithm, and the behaviors of the evolved controller were analyzed with a state transition diagram. The robot produces emergent behaviors by the interaction of fuzzy rules that came out from the evolution process. In [44], the authors suggested a three step evolution process to self-organize a fuzzy logic controller. The procedure initially tunes the output term set and rule base, then the input membership functions, and in the third phase it tunes the output membership functions. Hargas et al. in [45], suggested a fuzzy-genetic technique for the on-line learning and adaptation of an intelligent robotic vehicle. In [46] the authors present a methodology for tuning the knowledge base of the fuzzy logic controller based on a compact scheme for the genetic representation of the fuzzy rule base.

In [47] the authors present a scheme for the evolution of the rule base of a fuzzy logic controller. The evolution takes place in simulated robots and the evolved controllers are tested on a Khepera mobile robot. Nanayakkara et al. in [48], present an evolutionary learning methodology using a multi objective fitness function that incorporates several linguistic features. The methodology is compared to the results derived from a conventional evolutionary algorithm. An attempt to formulate a way of picking the suitable function for a task was made by Nolfi and Floreano in [49]. They suggested the concept of "fitness space", which provides a framework for the description and development of fitness functions for autonomous systems.

An important issue not addressed in the literature, is related to the selection of the fitness function parameters used in the evolution process of fuzzy logic controllers. The majority of the fitness functions used for controllers evolution are empirically selected and (most of times) task specified. This results to controllers which heavily depend on fitness function selection.

The experience in the design of the nonlinear position control confirmed the remarkable potential of fuzzy logic in the development of effective decision laws capable of overcoming the inherent limitations of model-based control strategies [50].

Lacevic and Velagic [50] focused on the design of the fuzzy logic-based position control of the mobile robot that both meets a good position tracking requirements and has practically achievable control efforts.

With our previously designed CLF based controller a good tracking performance has been obtained. However, its significant shortcoming is unsatisfactory velocity/torque command values, particularly at the beginning of tracking. Control parameters of the CLF-based controller and the membership functions of the fuzzy position controller are evolved by the genetic algorithms. The advantage of the offered fuzzy controller lies in the fact that the velocity

commands (and consequently, the torque commands) cannot exceed certain limits. Consequently, this controller radically decreased the control velocities without major impact on the tracking performance. Finally, from the obtained simulation results, it can be concluded that the proposed fuzzy design achieves the desired results. The future work will investigate the stability analysis of the system when the proposed fuzzy logic-based position controller is used.

VI. OTHER METHODS

Apart for the above commonly used methodologies, several other evolutionary approaches have also been tested in the ER field in recent years. For example, classifier systems have been used as an evolution mechanism to shape the robotic controllers [51], [52]. Grefenstette and Schultz used the SAMUEL classifier system to evolve anti-collision navigation [53], [54]. Katagami and Yamada [55] suggested a learning method based on interactive classifier system for mobile robots which acquires autonomous behaviors from the interaction experiences with a human. Gruau and Quatramaran [56] developed robotic controllers for walking in the OCT-1 robot using cellular encoding. In the work of Berlanga et al. [57], the ES has been adopted to learn high-performance reactive behavior for navigation and collisions avoidance. Embodied evolution has been offered as a methodology for the automatic design of robotic controllers [58], which avoids the pitfalls of the simulate-and-transfer method. Most of the aforementioned ER approaches are essentially software based.

Nowadays, hardware-based robotic controllers using artificial evolution as training tools are also being used. The development of evolvable hardware (EHW) has attracted much attention from the ER domain, which is a new set of integrated circuits able to reconfigure their architectures using artificial evolution techniques unlimited times. Higuchi, Iba, and Manderick [59] used off-line model-free and on-line model-based methods to derive robot controllers on the logic programmable device. Attempting to exploit the intrinsic properties of the hardware, Thompson [20] used a Dynamic State Machine (DSM) to control a Khepera robot to avoid obstacles in a simple environment.

Tan, Wang, Lee and Vadakkepat in [60] discusses the application of evolvable hardware in evolutionary robotics, which is a new set of integrated circuits capable of reconfiguring its architecture using artificial evolution techniques. Hardware evolution dispenses with conventional hardware designs in solving complex problems in a variety of application areas, ranging from pattern recognition to autonomous robotics.

VII. CONCLUSION

Free-navigating mobile robotic systems can be used to perform service tasks for a variety of applications such as transport, surveillance, firefighting, etc. For such robotic application systems, it is crucial to derive simple robotic behaviors that guarantee robust operation despite of the limited knowledge prior to system execution, e.g.,

designing anti-collision behavior that is effective in the presence of unknown obstacle shapes. In recent years, autonomous mobile service robots have been introduced into various non-industrial application domains including entertainment, security, surveillance, and healthcare. They can carry out cumbersome work due to their high availability, fast task execution, and cost-effectiveness.

An autonomous mobile robot is essentially a computational system that acquires and analyzes sensory data or exterior stimuli and executes behaviors that may affect the external environment. It decides independently how to associate sensory data with its behaviors to achieve certain objectives.

Such an autonomous system is able to handle uncertain problems as well as dynamically changing situations. Evolutionary robotics appears to be an effective approach to realizing this purpose. In this paper some applications of evolutionary approach in autonomous robotics are considered. A general survey is reported regarding the effectiveness of a variety of artificial evolution based strategies in robotics. Some questions need to be answered if evolutionary robotics is to progress beyond the proof-of-concept stage. Furthermore, future prospects including combination of learning and evolution, inherent fault tolerance, hardware evolution, on-line evolution, and ubiquitous and collective robots are suggested.

REFERENCES

[1] L. Wang, K. Chen Tan, Chee Meng Chew, "Evolutionary robotics: from algorithms to implementations," World Scientific Series in Robotics and Intelligent Systems., vol. 28, 2006.
[2] S. Nolfi, "Adaptation as a more powerful tool than decomposition and integration: experimental evidences from evolutionary robotics," Proceedings of the IEEE World Congress on Computational Intelligence, 1998, pp. 141 -146.
[3] D. Pratihar, "Evolutionary robotics – A review," Sadhana, vol. 28, Springer India, in co-publication with Indian Academy of Sciences, 2003, pp. 999–1009.
[4] T. Fukuda, Yasuhisa Hasegawa, "Evolutionary computing in robotics," Artificial Life and Robotics, vol. 6, Springer Japan, 2002, pp. 1-2.
[5] J.-A. Meyer, "Evolutionary approaches to neural control in mobile robots," Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics, 1998, pp. 2418 -2423.
[6] O. Chocron, P. Bidaud, "Evolving walking robots for global task based design," Proceedings of the International Congress on Evolutionary Computation, 1999, pp. 405-412.
[7] J. B. Pollack, H. Lipson, S. Ficci, et al., "Evolutionary techniques in physical robotics, Evolvable Systems: From Biology to Hardware," Lecture Notes in Computer Science 1801 (Proc. of ICES2000), Springer- Verlag., 2000, pp. 175-186.
[8] S. H. Huang, "Artificial neural networks and its anufacturing application: Part I," on-line, 2002.
[9] D. H. Ackley, M. L. Littman, "Interactions between learning and evolution. In Artificial Life II," edited by C. G. Langton, J. D. Farmer, S. Rasmussen, C. E. Taylor. Addison-Wesley. Reading, Mass., 1991.
[10] D. Parisi, S. Nolfi, "How learning can influence evolution within a non-Lamarckian framework. In Plastic Individuals in Evolving Populations," edited by R. K. Belew, M. Mitchell. SFI Series, Addison-Wesley, in press.
[11] O. Miglino, R. Pedone, D. Parisi, "A noise Gene for Econets," In Proceedings of Genetic Algorithms and Neural Networks, edited by M. Dorigo, Reading, Mass.: Addison Wesley, 1993.
[12] D. T. Cliff, I. Harvey, P. Husbands, "Explorations in Evolutionary Robotics," Adaptive Behavior, vol. 2, 1993, pp. 73-110.
[13] N. Jakobi, "Running across the reality gap: Octopod locomotion evolved in a minimal simulation," Proceedings of the First European

Workshop on Evolutionary Robotics 98 (EvoRobot98), France, 1998, pp. 39-58.

[14] R. D. Beer, J. C. Gallagher, "Evolving dynamic neural networks for adaptive behavior," Adaptive Behavior, vol. 1, 1992, pp. 91-122.

[15] N. J. D. Parisi, S. Nolfi, F. Cecconi, "Leaning, behavior and evolution," Proceedings of the First European Conference on Artificial Life, Cambridge, MA: MIT Press/Bradford Books, pp. 1992, 207- 216.

[16] D. Floreano, F. Mondada, "Evolution of homing navigation in a real mobile robot," IEEE Transactions on Systems, Man and Cybernetics – Part B, vol. 26 (3), 1996.

[17] A. Chohra, A. Farah and C. Benmehrez, "Neural Navigation Approach for Intelligent Autonomous Vehicles (IAV) in Partially Structured Environments," Applied Intelligence, vol. 8, Springer Netherlands, 1998, pp. 219-233.

[18] J. H. Holland, "Adaptation In Natural And Artificial Systems," Ann Arbor: The University of Michigan Press. 1975.

[19] J. R. Koza, "Genetic Programming II," The MIT Press, Cambridge, Mass., USA, 1994.

[20] A. Thompson, "Evolving electronic robot controllers that exploit hardware resources," Proc. of the 3rd European Conf. on Artificial Life (ECAL95), Springer-Verlag, 1995, pp. 640-656.

[21] I. Harvey, "Species Adaptation Genetic Algorithms: A basis for a continuing SAGA," Toward a Practice of Autonomous Systems: Proceedings of the First European Conference on Artificial Life, F. J. Varela and P. Bourgine (eds.), MIT Press/Bradford Books, Cambridge, MA, 1992, pp. 346-354.

[22] I. Harvey, "Artificial evolution: a continuing SAGA," T. Gomi, (ed.): ER2001, LNCS 2217, 2001, pp. 94-109.

[23] G. B. Parker, "The co-evolution of model parameters and control programs in evolutionary robotics," Proceedings of IEEE International Symposium on Computational Intelligence in Robotics and Automation, 1999, pp. 162 -167.

[24] J. F. Walker, J. H. Oliver, "A survey of artificial life and evolutionary robotics," 1997.

[25] T. E. Revello, R. McCartney, "A cost term in an evolutionary robotics fitness function," Proceedings of the 2000 Congress on Evolutionary Computation, 2000, pp. 125 -132.

[26] P. Dittrich, A. Burgel, W. Banzhaf, "Learning to move a robot with random morphology," Proceedings of the First European Workshop on Evolutionary Robotics (EvoRobot 98), France, 1998, pp. 165-178.

[27] F. Hoffman, T. J. Koo, O. Shakernia, "Evolutionary design of a helicopter autopilot," Proceedings of the 3rd On-line World Conference on Soft Computing, Cranfield, UK., 1998.

[28] P. N. Paraskevopoulos, "Digital Control Systems," Prentice Hall., 1996.

[29] D. Driankov, A. (Eds). Saffiotti, "Fuzzy Logic Techniques For Autonomous Vehicle Navigation," Springer-Verlag., 2001.

[30] A. SafBotti, "The uses of fuzzy logic in autonomous robot navigation," Soft Computing, Springer-Verlag, 1997, pp. 180-197.

[31] H. Hagras, V. Callaghan, M. Colley, "Outdoor mobile robot learning and adaptation," IEEE Robotics and Automation Magazine, 2001, pp. 53-69.

[32] C. T. C. Arsene, A. M. S. Zalzala, "Control of autonomous robots using fuzzy logic controllers tuned by genetic algorithms," Proceedings of the International Congress on Evolutionary Computation 1999, 1999, pp. 428-435.

[33] D. K. Pratihar, K. Deb, A. Ghosh, "Fuzzy-genetic algorithms and mobile robot navigation among static obstacles," Proceedings of the International Congress on Evolutionary Computation 1999, 1999, pp. 327-334, 1999.

[34] J. A. Driscoll, R. A. Peters II, "A development environment for evolutionary robotics," Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics, 2000, pp. 3841-3845.

[35] P. Xiao, V. Prahlad, T. H. Lee, X. Liu, "Mobile robot obstacle avoidance: DNA coded GA for FLC optimization," Proc. of 2002 FIRA Robot World Congress, Korea, 2002, pp. 553 – 558.

[36] M. Mucientes, D.L. Moreno, A. Bugarín and S. Barro, "Evolutionary Learning of a Fuzzy Controller for Mobile Robotics," Soft Computing , vol. 10, Springer Berlin / Heidelberg, 2006, pp. 881-889.

[37] L. Doitsidis, N. C. Tsourveloudis and S. Piperidis, "Evolution of Fuzzy Controllers for Robotic Vehicles: The Role of Fitness Function Selection," Journal of Intelligent & Robotic Systems, vol. 56, Springer Netherlands, 2009, pp. 469–484.

[38] N.C. Tsourveloudis, L. Doitsidis, K.P. Valavanis, "Autonomous navigation of unmanned vehicles: a fuzzy logic perspective," In: Kordic, V., Lazinica, A., Merdan, M. (eds.) Cutting Edge Robotics, 2005, Pro Literatur Verlag, Mammendorf, pp. 291–310.

[39] X. Yang, M. Moallem, R.V. Patel, "A layered goal-oriented fuzzy motion planning strategy for mobile robot navigation," IEEE Trans. Syst. Man Cybern., vol. 35(6), 2005, pp. 1214–1224.

[40] P. Resu, E.M. Petriu, T.M.Whalen, A. Cornell, H.J.W. Spoelder, "Behavior-based neuro-fuzzy controller for mobile robot navigation," IEEE Trans. Instrum. Meas., vol. 52(4), 2003, pp. 1335–1340.

[41] N.C. Tsourveloudis, K.P. Valavanis, T. Hebert, "Autonomous vehicle navigation utilizing electrostatic potential fields and fuzzy logic," IEEE Trans. Robot. Autom., vol. 17(4), 2001, pp. 490–497.

[42] C. Ye, N.H.C. Yung, D. Wang, "A fuzzy controller with supervised learning assisted reinforcement learning algorithm for obstacle avoidance," IEEE Trans. Syst. Man Cybern., vol. 33(1), 2003, pp. 17–27.

[43] S.-I. Lee, S.-B. Cho, "Emergent behaviors of a fuzzy sensory-motor controller evolved by genetic algorithm," IEEE Trans. Syst. Man Cybern., vol. 31, 2001, pp. 919–929.

[44] S.H. Kim, C. Park, F. Harashima, "A self-organized fuzzy controller for wheeled mobile robot using an evolutionary algorithm," IEEE Trans. Ind. Electron., vol. 48(2), 2001, pp. 467–474.

[45] H. Hagras, V. Callaghan, M. Colley, "Learning and adaptation of an intelligent mobile robot navigator operating in unstructured environment based on a novel online fuzzy-genetic system," Fuzzy Sets Syst., vol. 141, 2004, pp. 107–160.

[46] F. Hoffman, G. Pfister, "Evolutionary design of a fuzzy knowledge base for a mobile robot," Int. J. Approx. Reason., vol. 17(4), 1997, pp. 447–469.

[47] V. Matellan, C. Fernadez, J.M. Molina, "Genetic learning of fuzzy reactive controllers," Robot. Auton. Syst., 1998, vol. 25, pp. 33–41.

[48] D.P.T. Nanayakkara, K. Watanabe, K. Kiguchi, K. Izumi, "Evolutionary learning of a fuzzy behavior based controller for a nonholonomic mobile robot in a class of dynamical environments," J. Intell. Robot. Syst., vol. 32, 2001, pp. 255–277.

[49] S. Nolfi, D. Floreano, "Evolutionary Robotics: The Biology, Intelligence, and Technology of Self-Organizing Machines," MIT, Cambridge 2000.

[50] B. Lacevic, J. Velagic, "Evolutionary Design of Fuzzy Logic Based Position Controller for Mobile Robot," Journal of Intelligent & Robotic Systems, vol. 63, Springer Netherlands, 2011, pp. 595-614.

[51] M. Dorigo, M. Colombetti, "Robot shaping : Developing autonomous agent through learning," Artificial Intelligence, vol. 71, 1994, pp. 321-370.

[52] M. Dorigo, U. Schnepf, "Genetics-based machine learning and behavior-based robotics: A new synthesis," IEEE Transactions on Systems, vol. 23, Man, Cybernetics, 1993, pp. 141-154.

[53] J. J. Grefenstette, "Incremental learning of control strategies with genetic algorithms," Proceedings of the Sixth International Workshop on Machine Learning, 1989, pp. 340-344.

[54] J. J. Grefenstette, A. Schultz, "An evolutionary approach to learning in robots," In Proceedings of the Machine Learning Workshop on Robot Learning, 1994.

[55] D. Katagami, S. Yamada, "Interactive classifier system for real robot learning," Proceedings of the 2000 IEEE International Workshop on Robot and Human Interactive Communication, Japan, 2000, pp. 258-263.

[56] F. Gruau, K. Quatramaran, "Cellular encoding for interactive evolutionary robotics," Proceedings of the Fourth European Conference on Artificial Life. The MIT Press/Bradford Books, 1997.

[57] A. Berlanga, P. Isasi, A. Sanchis, et al., "Neural networks robot controller trained with evolution strategies," Proceedings of the International Congress on Evolutionary Computation, 1999, pp. 413-419.

[58] R. A. Watson, S. G. Ficici, J. B. Pollack, "Embodied Evolution: Embodying an evolutionary algorithm in a population of robots," Proceedings of the 1999 Congress on Evolutionary Computation, 1999.

[59] T. Higuchi, H. Iba, B. Manderick, "Applying evolvable hardware to autonomous agents," Parallel Problem Solving From Nature (PPSNIII), 1994, pp. 524-533.

[60] K.C. Tan, L.F. Wang, T.H. Lee and P. Vadakkepat, "Evolvable Hardware in Evolutionary Robotics", Autonomous Robots, vol. 16, Springer Netherlands,2004, pp. 5–21.

Development of Computer-Aided Thermal Procedures of Technical Objects

Ihor Farmaga, Uliana Marikutsa, Jan Wrobel, Andriy Fabirovskyy

Abstract — **The popularities of the development of design procedures and thermal design operations for the construction of a general structure of a computer-aided thermal design of technical objects with the aim of providing their thermo-physical characteristics are described.**

Index Terms — **thermal design, technical object, thermal model.**

I. INTRODUCTION

The general process of the development of technical objects (TO) can be described in stages and levels of decomposition, each of which corresponds its problems of designing of technical objects. During the solving of these problems for technical objects, the peculiarity of which demands taking into consideration thermal regimes and providing temperature stability within the process of their functioning, it is necessary to put subproblems, which form in general the process of thermal design

II. PECULIARITIES OF DESIGN PROCEDURES AND OPERATIONS DEVELOPMENT

The design procedure of the thermal design of technical objects is considered in close correlation with the design procedures of scheme and constructionally – technological levels of designing and is described separately with the aim of development of its general structure, that is used during the solving of different problems. Let's describe project operations, which are components of the project procedure (Fig. 1).

Solution of thermal design problems is closely connected to modeling and analyzing the thermal conduction [1, 2]. That's why the first project operation is modeling, the result of which is a thermal model of the technical object, the second one is receiving the additional information by using subsystems of the scheme constructional and technological design. The third operation is the analysis. The result is a temperature field of the construction or the index of temperature of the elements of the technical object.

The development of criteria and macromodels for finding scheme, constructional or technological solutions is done further. The last operation is finding the design solution.
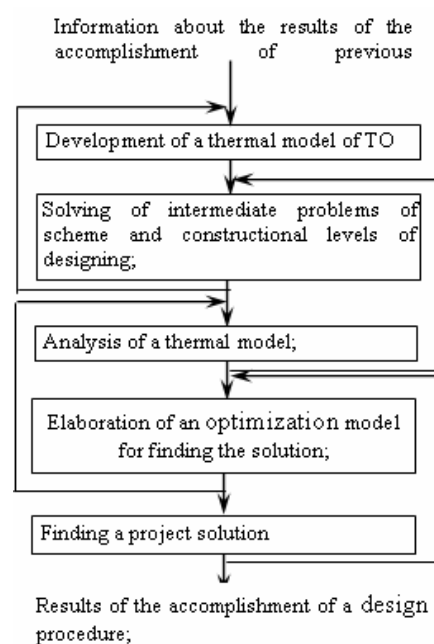
Fig. 1. Structure of heat design procedure in a continuous cycle of a TO design

The computerization of the thermal design process of technical objects claims for the development of methods which are characterized by such peculiarities:

– possibility of gaining adequate results with simultaneous simplicity of the method of problem solution;

– possibility of the computerization of the process of preparation the input data. For thermal models and design procedures;

– possibility of the improvement of received and the development of new mathematical models, algorithmic and computational models;

– quickness in finding solutions within the process if designing;

– use of various methods at all problem solving levels – from model construction to receiving design solutions.

According to system-structural approach the process of modeling and analysis of thermal conditions could be divided to such stages (Fig. 2):

1. Thermal model construction, that is an acceptance of assumption to geometrical version of technical object construction;

2. Description of physical processes in the given geometrical model;

3. Transformation and reduction of the primary mathematical model;

4. Choice of method and convergence of mathematical model to the system or the sequence of specified functions;

5. Acquisition of function meaning;

6. Acquisition of technical object thermal condition

In each stage specified methods could be used for getting results [1]. Subject to the necessary degree of problem detailing, the presence of technical means, the organizational base and the methodical provision, either one or another method is used (Fig. 2).
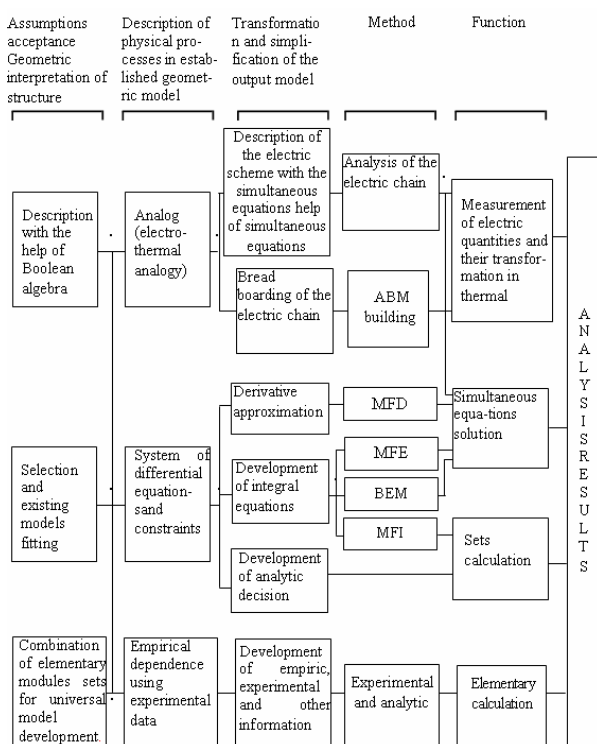
Fig. 2. Phases and methods of temperature fields models development and analysis

It may be noted that there are three basic strategies of thermal regimes analysis. They are – mathematical modeling, which is based on the use of digital computer techniques, analog methods, which are based on the electrothermal analogy and the construction of specialized analog computers (AOM) experimental-computational methods, which are widely used for the building of simple engineering methodologies that do not require complicated computer equipment, but the availability of this equipment and highly skilled engineering staff with extensive experience is expected. Advantages and disadvantages of these methods are known..

In most cases, a digital computer technique is used as the universal mean of automation under conditions of automated design methods integration into common system.

Therefore, mathematical methods are emphasised in modeling of thermal regimes. The abstract of these methods, which are divided into analytical and numerical, is given in [32]

Methods division to analytic methods and numeral methods is very relative, especially in cases of receiving analytic dependence of coordinates and time during resolving problem, while coefficients of this dependence are represented in numeral form. Results of the numeral problem solution could be approximated by analytical dependences for further processing and vice versa – results which were received in analytical form could be represented in charts of numeral meanings.

Each methods of mathematical modeling problem solution have its advantages and disadvantages. The reduction of one or another method to the universal method puts to heavy expenses for algorithm development and making calculation.

Notice cited above, as to wide possibilities of automatization and computing machinery, we suggest, according to generalization of various methods characteristics and possibilities, to construct methods which combine rational compromise between mathematical, analytical and numeral methods of mathematical model development and algorithm analysis of thermal conditions in all levels. The practices confirm a necessity of such an approach, because often during the development of new modeling methods we use one or more classic methods.

The input data for development of computer-aided thermal conditions is its qualitative and quantitative determination. The qualitative determination is a type of thermal model with a primary and limit condition. The quantities determination is a degree of necessary adequacy to the real construction and functioning conditions.

The method structure is determined by special features of procedure and by its place in the process of thermal design.

The main problem during the development of the 4th and the 5th operation consists in a solution of contradictions between such factors:

1. Maximum possible use of available software methods of optimization and increased demands of receiving results efficiency.

2. Increase of automatization process degree of receiving design solution and maximum use of developer empirical experience;

3. hugeness and complexity of thermal process mathematical models in technical objects constructions and necessity of multiple calculation.

It is recommended to use an approach, which is based on half-heuristic designing methods, to solve formulated problem [3]. Hence, we can notice such specific features of operation development:

1. Based on real designing process we should develop a set of optimization models;

2. To formalize partial problems of thermal-physic characteristic provision of technical objects based on use of existing computer-aided methods of optimum designing;

3. To develop optimality criteria's and to describe searching fields of optimal solutions;

4. To provide the possibility of designer's solution acceptance based on the generalization of analysis results computer-aided processing of thermal conditions, results of optimization problems solution.

The degree of given contradictions solving is marked by general demands accomplishment.

Now, when special designing features, the analysis of thermal conditions and technical objects designing are defined, let's look at the 2nd procedure operation of thermal designing.

As a result of procedure accomplishment we should receive not only input data which is describing energy, topological, constructional characteristic of thermal objects (TO), but also possible change limits, variants of components placement, the design grouping. Judging from features of further procedures development we should receive the maximum quantity of information. Such an approach let us reduce the quantity of access to mathematical model of thermal field. So that during the 2nd operation accomplishment we can form the input data which meets conceptual object model and includes data which is necessary for achieving the goal. The mathematical model should meet demand of adaptation and invariance to the input data.

III. The Structure Of Process And Automated System Of Technical Objects Thermal Design

The diversity of thermal design problems, which are realized in the form of procedures, the need for flexibility in the structure of the process, ensuring the relationship with design procedures and circuit design and process design at the level of input, output data and mathematical models of the formalization process involves thermal design based on a systematic approach in the form of set-theoretic relation. Automation of thermal design provides the development of automated systems, concrete realization of the logical structure of the process, models, algorithms and programs. Implementation of thermal design in the form of an automated system which is used independently or in an environment of integrated computer aided design is carried out by developing its key components that meet generally accepted components of CAD and general conceptual framework construction, operation, and maintenance systems. Thus, there are two categories - system in the form of a formal description of the thermal design and automated system, where the process occurs. The first system - a process of thermal design, which consists of the design procedures, operations, models, methods, and converts the input data in the results (Fig. 3).

The second system - organizational technical system for implementing thermal design in a computer-aided drafting of technical objects.
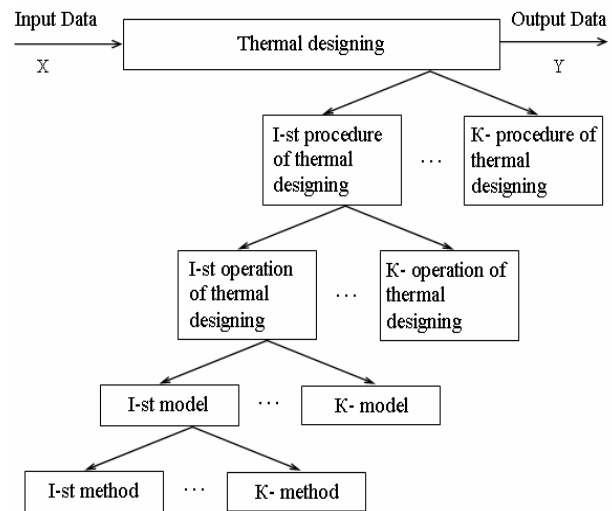
Fig.3. Hierarchical structure of thermal designing process.

Here the formal structure of the thermal design process is described. It is represented as a set:

$$M = \{X, Y, P, Q\} \qquad (1)$$

Where: X – set of descriptions of the input object design; Y – set of input data (a set of design decisions made based on analysis of thermal characteristics; P – set of design procedures of thermal design; Q – the set of communication systems.

Set of the original description of the object served as:

$$X = < Xcx, Xk, Xtex, Xct, Xtep, Xf > \qquad (2)$$

where Xcx – the circuit data, which include input and output circuit design; $Xк$ – Design data; $Xtex$ – Technological data; Xct – Structural parameters; $Xtep$ - Thermal characteristics; Xf – Functional parameters;

$$Y = < Ycx, Yk, Ytee > \qquad (3)$$

where: Ycx – the result of the thermal design of circuit stage; Y_K – The result of the design phase of the design; $Ytee$ – The result of technological development, Yi, $i \in \{cx, k, tee\}$

And the decision, based on an analysis of temperature field and thermal characteristics of technical objects Y_a

$$Yi \subseteq Ya \cap Y_j^p \quad | \quad j \in \{cx, k, tee\} \qquad (4)$$

where Y_j^p – the result of the circuit feasibility, design or technological design.

We shall describe a set of design procedures:

$$P = P_T \bigcup P_P \qquad (5)$$

where P_T – the theoretical basis of building design procedures; P_P – realization of a theoretical basis in specific kinds of CAD.

$$P_T = \bigcup_{ki=1}^{n1} Pnn_{k1} ; \quad Pnn = \bigcup_{k2=1}^{n2} Pno_{k2} ;$$

$$\text{Pno} = \bigcup_{k3=1}^{n3} \text{Mo}_{k3} \; ; \; \text{Mo} = \bigcup_{k4=1}^{n4} \text{Ma}_{k4} \; ; \quad (6)$$

Thus P_T served as a hierarchical structure in which: P_{nn} – The design process; P_{no} – Project operation; M_o – Object model design; M_a – Methods of analysis and decision making,

$$\text{Pp} \subseteq < O, M_T, L, I, P_r, M_a, T >, \quad (7)$$

where O – organizational, M_T – Methodological, L – Linguistic, I – Informational, P_r – software, M_a – mathematical, T – technical support for CAD.

The set of relations is the union of three subsets:

$$Q = Q_z \bigcup Q_V \bigcup Q_M, \quad (8)$$

where Q_z – the external relations of thermal design with integrated CAD technical subjects; Q_V – Internal links between design procedures; Q_M – Direct contact with circuit procedures, design, process design at the level of mathematical models (e.g., problem solving analysis and optimization schemes of technical object formed macromodel that allows to carry out the calculation of local overheating of the elements in order to access the source temperature characteristics.

Finally, describe the structure of M, note that its four main components are in the functional dependence, thus forming a formal system thermal design

$$S : Y = F(X), \quad (9)$$

where $F \subseteq P \times Q$.

Consider the practical implementation of a formal system S as the organizational and technical, which makes it possible to make thermal design of technical objects. One of the main requirements for an automatic system thermal design is its adaptability to the real process of developing devices and which, in turn, use software-implemented mathematical models and methods for specific tasks to perform procedures and results of the overall process.

Based on this section of functional automated system for following components:

1) program-methodical complex, which consists of a processor, preprocessor and post processor, interface information and monitor;

2) hardware (servers, workstations, devices, document text and graphic information);

3) organizational support, which brings together users of the system design and specific conditions.

Processor contains program-implemented mathematical models: used to analyze thermal characteristics of technical objects, making decisions, forming macromodels thermal characteristics of technical systems for object circuit, design and technological design, focused on a wide range of tasks; adaptation to decision specific tasks using the input data, which are received on the input of the processor. The processor implements the mathematical system.

Preprocessor system implements the following functions: formation of the information model for the processor based on the analysis type of problem that is solved, automated construction of thermal models is based on a conceptual model of the object and design in accordance with the stages and phases of design, content and modification of local database systems heat design, ensuring links with systematy circuitry, design and technological design; addition of other autonomous systems software packages and calculation of thermal modes of components and component technical objects.

Posprotsesor system thermal design implements the following functions: interpretation of graphic design as a one-two-and three-dimensional features on your workstation or device documentation, visualization and documentation in tabular form the results of design.

Information interface acts as a local database system and serves to store and exchange between components of the system thermal design as input data that describe the object of design, and intermediate and final results of the design. Because information is data exchange interface with the components of an integrated CAD technical objects.

Preprocessor, postprocessor, the information interface implementing information support system.

Monitor system thermal design is realized using the standard operating systems and allows interactively or in batch mode to challenge the system components in any order.

This approach enables you to organize your system with a software operating environment of workstations and work in a computer network (a server) is using the machine-oriented language for writing special programs. This increases the efficiency of installing the system thermal design on the platform of any type.

IV. CONCLUSION

A detail consideration of designing procedure development features and thermal designing operations let us develop the computer-aided thermal designing structure, to choose necessary methods, to develop appropriate models and methods of thermal conditions analysis of technical objects, furthermore decision acceptance with the aim of providing their thermal-physic characteristics.

REFERENCES

[1] Kuzhydlovskyy K. Information and calculation method for determining the thermophysical characteristics of composite materials / Krzysztof Kuzhydlovskyy, Marian Lobur, Farmaha Igor, Oleg Matviykiv / / Bulletin of NU "Lviv Polytechnic" Computer systems design. Theory and Practice. 2010. № 626. C. 16 - 21.

[2] Farmaha I. The solving of heat transfer problem of composite materials by finite element method / I. Farmaha, U. Marikutsa, P. Shmigelskyi // CAD in Mashinery Design. Inplementation and Education Problems (CADMD'2010) : Proc. of the XIX Ukrainian-Polish Conference. - Lviv, 2010. – P. 124 - 125.

[3] Automating exploratory design (Artificial Intelligence in engine design) / Polovinkin A., Bobkov N., Bush G. and others. M.: Radio and communication, 1981. 344 p.

Farmaga Ihor Viroslavovych
Ph.D., assistant professor of CAD
E-mail: farmaga (at) polynet.lviv.ua
Education
Lviv Polytechnic Institute, Radio School, 1983;
Graduate School, Lviv Polytechnic Institute, 1993;
PhD thesis "Development of adapted models and methods for thermal design of integrated CAD microelectronic devices", Lviv Polytechnic Institute, 1993.
Professional activities:
from 1986 - junior researcher RL-61;
1987 - Fellow BSRL MEP CAD;
from 1992 - Assistant Professor of CAD;
Since 1994 - Senior lecturer in CAD;
from 1999 - present - Associate Professor of CAD.
Research interests:
Development of mathematical models of heat transfer processes in microelectronic devices, microelectromechanical systems modeling, development of CAD components, development of automated learning systems.

Marikutsa Uliana Bohdanivna
Ph.D., assistant professor of CAD
E-mail: marikutsa (at) polynet.lviv.ua
Education
1998 graduated from the Master of the State University "Lviv Polytechnic" specialty "Information Systems Design"
PhD thesis "Information-measuring system for fast detection of toxic chemicals in the air," National University "Lviv Polytechnic", 2009.
Professional activities:
2000 - 2003 - Lviv kinotehnikum - teacher kom'yuternyh disciplines;
2003 - 2008 - assistant department CAD
2008 - 2010 - Senior lecturer in CAD
2010 - present - Associate Professor of CAD;
Research interests:
Thermal design, development of information measuring systems.
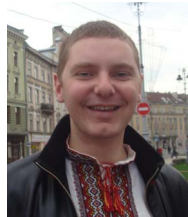
Fabirovskyy Andriy,
student of Lviv Polytechnic National University, department of applied linguistics, Master Ddegree is due in December 2012.
Activities:
development of linguistic support for thermal designing systems;
studying foreign languages (Japanese, English, Polish);

Problems of Developing Web Systems for Evolutionary Computation

Rostyslav Kryvyy, Serhii Tkachenko, Volodymyr Karkuljovskyy

Abstract – **This article discusses the features of cross-platform technologies to develop systems of evolutionary computing. In this paper deals with popular frameworks that simplify the implementation of software products based on genetic algorithms**

Index Terms – **Computer aided analysis, Genetic algorithms, Open source software, Web services.**

I. INTRODUCTION

Today, the problems of searching of optimal solutions undoubtedly increase their urgency and significance. The need for decision making of different importance grows, rises responsibility for the solutions accepted, and their consequences become more significant.

In addition, there are many problems that can not be resolved with traditional methods, which makes an important development and analysis of algorithms evolutionary type [1,2].

II. WHAT IS GENETIC ALGORITHMS

The name of the algorithm, because it lies at the basis of simulation of processes occurring in nature, among individuals of any population. The individual is a solution, encoded in an arbitrary manner, such as a binary string. The set of solutions at a fixed time of a population. Individuals current population compete with each other for the transfer of its genetic information (the creation of offspring) in the next population. Selected individuals from the current population by selection, are the steps for creating new solutions to its children - recombination and mutation. The basic operators of genetic algorithm called crossover operators, selection and mutation. It is known that GA has a global convergence (Fig. 1).

Manuscript received October 9, 2011.

Rostyslav Kryvyy is with CAD Department, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, (corresponding author to provide phone: +38 (032) 258 21 02; fax: +38 (032) 258 26 74; e-mail: kryvyj@polynet.lviv.ua)

Serhii Tkachenko is with CAD Department, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, (corresponding author to provide phone: +38 (032) 258 21 02; fax: +38 (032) 258 26 74; e-mail: sptkach@gmail.com)

Volodymyr Karkuljovskyy is with CAD Department, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, (corresponding author to provide phone: +38 (032) 258 21 02; fax: +38 (032) 258 26 74; e-mail: vak@polynet.lviv.ua)

In addition, genetic algorithms are probabilistic (stochastic) process. To analyze the effectiveness of their work should be carried out a statistical averaging over several launches. The quality of the GA will be judged on three criteria in order of importance: reliability, speed, range (range of generations in which the solution is found).
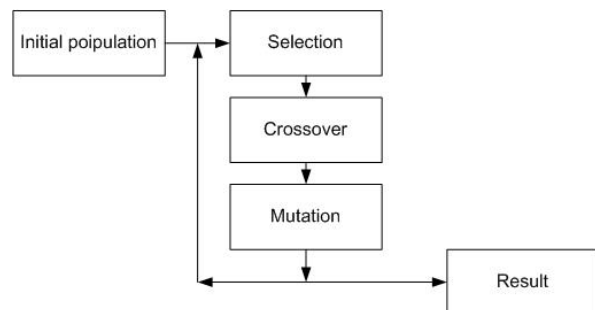
Fig. 1. A very simplified view of genetic algorithms

III. PROS AND CONS OF GENETIC ALGORITHMS

Features of GA: GA are not only just random search. They effectively use information accumulated during the evolution process. The main advantage of evolutionary modeling is possibility of solving of tasks that have many local optimums at the expense of combining of elements of randomness and directivity in exactly the same way as it is in nature[2].

GA differ from other optimization and searching procedures in given below:

• They mostly work not with task's parameters but with coded set of parameters.

• The search is performed not in way of improving of one solution but with the help of usage at once few alternatives on set of solutions.

• Usage of objective function but not its various gains for estimation of making decisions quality.

Features of genetic algorithm's design: Genetic algorithm's design includes main components given below: design of structure, principle of coding and decoding of chromosomes, main genetic operator's design, and design of common structure of genetic search.

On software support and Result of GA affects number of factors [3]:

• Design of almost each GA is ground on stages of solution's coding and decoding in the form of genes and

chromosomes. For this process it is mainly used experience of previous realizations.

- Software support of each GA is made almost from the very beginning that is why all earnings from previous projects mainly are lost.

- Designers often use only the most widespread schemes of GA and genetic operators after what they design simplified variants of GA's usage for certain task.

Similar to the rest algorithms genetic algorithm has its advantages and disadvantages. One of its greatest pluses is wide range of the application fields that enables to use it for different classes' tasks solving. Genetic algorithms are adopted for diverse dimension tasks solving. Genetic algorithm can be realized with the help of problem-oriented programming that gives lots opportunities for ideas of problem-oriented design realization. Nevertheless there are reasons that complicate development and realization of genetic algorithms. In fact it is needed to realize new genetic algorithm for particular task, realize and decode decision again. Its heuristic character also can be taken as disadvantage and it does not guarantee globally optimal decision. And about high computing complexity – you can take it in with paralleling of computing process [4].

IV. THE CURRENT STATE OF SOFTWARE DEVELOPMENT FOR GENETIC ALGORITHMS

Software products that use genetic algorithms can be divided into several major categories [1, 5]. The first category of software - packages that implement classical genetic algorithm with the possible configuration options, the basic operators of genetic algorithms. Model chromosomes in these packages is usually the standard binary structure, and selection is given a mathematical expression. The second category of programs are specialized programs designed to solve specific problems. These genetic algorithms are designed and optimized to address a narrow, clearly defined problems. The third category of development on genetic algorithms including research that is to investigate the properties and characteristics of different genetic algorithms and their convergence degeneracy.

V. FEATURES OF WEB SYSTEMS

Analysis of the current state of the software showed that the program can be divided into three categories, namely:

– Client programs that are installed on each user's machine.

– Client programs that are installed on each user's machine, and data processing occurs on a separate server (using client-server technology).

– Client programs that use a web-browser, and the application server is a web-server.
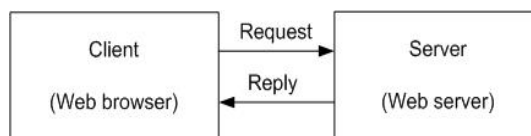
Fig.2. A very simplified view of web technology

The most promising one appears to be a system that is created on the basis of technology that uses a web-browser. This popularity is due to the fact that the World Wide Web has become a global communication system for delivering information and services, including software and web applications, which have become one of the mostly growing areas. Such systems have a lot of advantages [3,6]:

a) convenience when upgrading – upgrading is conducted only on the servers, which requires less time and effort, and facilitates the maintenance system;

b) ease of scaling – there is no need to install any additional software when you want to run a program. Everything you need is a web-browser, which is present in any operating system (OS), and access to the server via LAN or the Internet;

c) cross-platform support – the system does not depend on the type of operating system installed on the user's machine.

Among the advanced technologies that are most suitable for solving such problems is most suitable technology for Adobe AIR [7]

This technology is a platform-independent operating environment. The program, written with AIR, can be run not only in the browser, but as a normal desktop application.

AIR enables to convert existing Web services by using Flash, ActionScript, HTML or JavaScript, to traditional PC program. Typically, web services store user data on their servers. On the other hand, the ability to save your information on your own PC is often very important for the user. AIR applications also have the opportunity to work without Internet connection.

Application written using AIR can be run on multiple platforms for which Adobe or its partners deliver runtime environment, namely: Microsoft Windows NT (XP, Vista, 7), Mac OS X (PowerPC and Intel), Linux, Android.

The advantages of this technology are the following:

a) with AIR you can easily transfer ready HTML or Adobe Flex application on the user's computer;

b) additional access to the file system, clipboard, drag-and-drop technology.

Genetic algorithm is a search procedure based on the mechanism of natural selection and inheritance. They are used in various ways to solve many scientific and technical problems. Despite the enormous interest in the field of evolutionary computations, the number of actual working programs in this area is quite small. Work in this area can be divided into several major categories. [2] But all these programs are installed on each user's computer individually.

VI. DEVELOPMENT OF A WEB-SYSTEM

Having analyzed the most popular system for the implementation of evolutionary computation was selected key indicators on which to resist the development of modern systems [8].

The system should be simple in use of. This requires the design of user interface pay attention to the features and use the control system.

The system should be also include visualization of genetic algorithm that simplify work and give information about the optimization algorithm and work as well for advanced students. Also sells output estimates, each individual and generation.

The system should be flexible to adjust the various modifications of parameters of genetic operators.

Developers should provide extensibility of the system. In the case when users want to supplement the system with their algorithms.

Since the user wants to analyze the obtained data, the system must provide output data for further processing. Best suited for this XML-format files, which will consist of two parts. The first should describe the problem and the second to bring the characteristics of each generation (parameters operators, fitness evaluation of each generation, and special information about the best and worst individuals, including genotype, phenotype). This file will also be very useful when you get a good result in the optimization and can not remember every option instead of installing all options, the user can simply download the file playback and playback optimization.

Some of these features implemented in web-based graphical user interface for evolutionary algorithms which is called EA (Evolutionary Algorithm) Sandbox (Fig.3). [9]
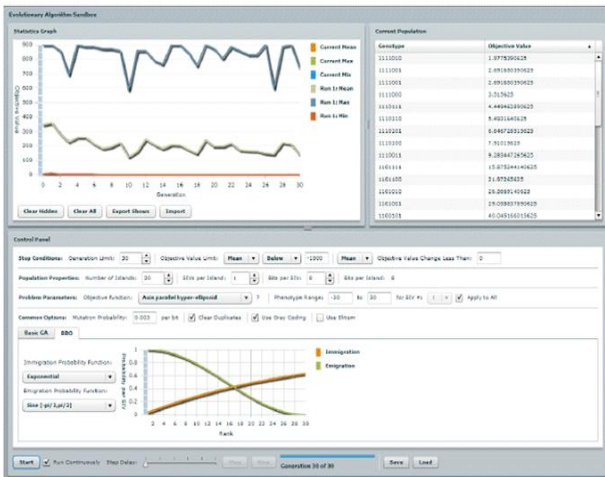
Fig.3. Evolutionary Algorithm Sandbox- a Web-Based Graphical User Interface for Evolutionary Algorithms

VII. FRAMEWORK FOR IMPLEMENTING GENETIC ALGORITHMS

Framework is ready to use complex software solutions, including design, logic and basic functionality of the system or subsystem. According software framework may include also support programs, some library code, scripts and generally anything that facilitates the creation and combination of various components of large software or rapid creation of finished and do not necessarily great software. Library - a collection of objects or routines for solving similar problems on the subject. The library contains the original code and data to support integration of new features in software solutions.

The powerful frameworks for develop genetic algorithms with large functional capabilities are given in Table 1.

This description does not deserve to be complete. As with every year of work in this area increases.

Every year the number increases frameworks, and their functionality improved. But the realization of software and systems using developed frameworks should remember that the efficiency of genetic algorithm in solving a specific problem depends on many factors, particularly of such as genetic operators and selection of appropriate parameters, and also a representation of the solution on the chromosome. Optimization of these factors leads to increased speed and stability of the search, which greatly affect the application of genetic algorithms [3, 5].

VIII. CONCLUSION

Relying on its advantages, the developed web-based systems will give the possibility to simplify the usage of genetic algorithms for optimization problems. They possess the following advantages: convenience when upgrading software, ease of scaling, cross-platform support, and access to the system from any computer with a global network.

Further development of this system involves expanding types of the tasks that can be solved by genetic algorithms.

TABLE 1
GENETIC ALGORITHMS FRAMEWORKS

Name	Date release	Programming language	Features
Open BEAGLE 3.0.3 [10]	29.11.2007	C++	Provides high-level software environment for performance of any evolutionary computation, with support for genetic programming, bit string, integer vectors in genetic algorithms, and evolutionary strategies.
JGAP (java genetic algorithms packege) 3.5 [11]	10.12.2007	Java	Provides basic evolutionary principles that can be easily used for solving problems.
Genetic Algorithms Framework 0.7.0 [12]	17.7.2009	Java	Allows to implement various complexity of genetic algorithms
Watchmaker Framework 0.7.1 [13]	15.1.2010	Java	Use of parallelism to improve performance on multicore and multiprocessor machines. Allows you to realize the evolutionary processes of different complexity, etc.
Pyevolve 0.6 [14]	12.5.2010	Python	Uses basic operators of genetic algorithm; gives new statistics, graphs and so on.
PGAPack 0.1 [15]	1.7.2010	Python.	Allows to implement parallel genetic algorithms
AForge.NET 2.1.5 [16]	11.1.2011	C#	Aimed at solving various problems of genetic algorithms and genetic programming; different types of chromosomes (binary, arrays), and algorithms (elitism, selection, etc.)
Evolving Objects (EO) 1.2.0 [17]	5.2.2011	C++	Flexible design that allows you to easily create virtually any algorithm different types of chromosomes (binary, arrays), and algorithms (elitism, selection, etc.)

REFERENCES

[1]. Rostyslav Kryvyy. Analysis of Frameworks for Developing Genetic Algorithms / Rostyslav Kryvyy, Serhii Tkachenko, Volodymyr Karkuljovskyy. Proc.of the VIIth International Conference MEMSTECH'2011 – Lviv – Polyana. 2011. pp. 209-210. p32
[2] [Goldberg D.E. Genetic Algorithms in Search, Optimization and Machine Learning. – Addison-Wesley, MA. – 1989.
[3] Lobur M. System's structure design for genetic search / M. Lobur, S. Tkatchenko, R. Kryvyy, I. Darnobyt // Proc. of the 5th International Conference of Young Scientists MEMSTECH. – Lviv–Polyana, 2009. – P. 60.
[4] Kryvyy R. Factors of influence on genetic algorithm's work in MEMS design / R. Kryvyy, M. Lobur, S. Tkachenko, I. Darnobyt // Proc. of the X-th International Conference CADSM. – Lviv–Polyana, 2009. – P. 327.
[5] Kryvyy R. Analysis of existent systems in researching genetic algorithms / R. Kryvyy, M. Lobur, S. Tkatchenko // Proc. of the XV Ukrainian-Polish CADMD. – Krasiczyn (Poland), 2009. – P. 24-25.
[6] Antonov YS Computer testing system based on technology three-database / Information Technology and Teaching Issue 2 (6), Kyiv, 2008.
[7] http://www.adobe.com/products/air.html
[8] Krivoy R.Z. Design subsystem for the study of genetic algorithms using templates / R.Z. Krivoy, M. Lobur, S. Tkachenko // Bulletin of the National University "Lviv Polytechnic" Computer systems design. Theory and Practice." 2009. № 651. P. 182-186.
[9] Gardner B.G., Simon D. Evolutionary algorithm sandbox: A web-based graphical user interface for evolutionary algorithms. Systems, Man and Cybernetics, 2009. SMC 2009. IEEE International Conference on Issue Date: 11-14 Oct. 2009 On page(s): 577 - 582
[10] Open BEAGLE - http://beagle.gel.ulaval.ca/
[11] JGAP (java genetic algorithms packege) - http://jgap.sourceforge.net/
[12] Genetic Algorithms Framework - http://sourceforge.net/projects/ga-fwork/
[13] Watchmaker Framework - http://watchmaker.uncommons.org/
[14] Pyevolve - http://pyevolve.sourceforge.net/
[15] PGAPack - http://pgapy.sourceforge.net/
[16] AForge.NET - http://www.aforgenet.com/
[17] Evolving Objects (EO) - http://eodev.sourceforge.net/

Dr. Rostyslav Kryvyy is a Associate Professor of Computer-Aided Systems Department of Computer Science and Information Technology Institute of Lviv Polytechnic National University.

Date of his birth is 25.03.1985, Zbarazh (Ukraine).

Education and Degrees Received:

2001 - 2006 – Master Degree of computer science , Lviv Polytechnic National University, Lviv (Ukraine);

2006 – 2009 – Ph.D. student: in Computer-Aided Design, Lviv Polytechnic State University, Lviv (Ukraine);

2010 – Ph.D. in Computer-Aided Design, Lviv Polytechnic State University, Lviv (Ukraine).

Professional Activity:

2010 - present – Assistant Lecturer, Lviv Polytechnic National University, Lviv (Ukraine);

Research interests are Design and programming of genetic algorithms, More than 25 publications, scientific-research papers and conference proceedings.

Information Security System Survivability Assessment Method

Valeriy Dudykevych, Iurii Garasym

Abstract —**The paper is devoted to creating an approach of designing embedded information security systems with survivability property.**

Index Terms—**information security system, survivability assessment, survivability property.**

I. Introduction

THE growing number of instances of breaches in information security in the last few years has created a compelling case for efforts towards secure electronic systems. Embedded systems, which will be ubiquitously used to capture, store, manipulate, and access data of a sensitive nature, pose several unique and interesting security challenges. Security has been the subject of intensive research in the areas of cryptography, computing, and networking. However, security is often mis-construed by embedded system designers as the addition of features, such as specific cryptographic algorithms and security protocols, to the system. In reality, it is an entirely new metric that designers should consider throughout the design process, along with other metrics such as cost, performance, and power [1].

Considering uncertainty situations, destabilizing factors (DF) influences, probable system structural elements (SE) failures requires survivability assessment as an information security systems (ISS) functioning efficiency characteristic [2]. Transition to ideology of survivable ISS designing and development allows: to achieve the general-purpose function in pre-contingency operating conditions, to provide ISS adaptive management, to build ISS on a "what if" schemes instead traditional "defence from" schemes that are inefficient in distributed ISS [3].

The survivability assessment models and methods developing is actual to improve functioning quality under the uncertainty DF influences for embedded systems security [4].

Valeriy Dudykevych is with Information Security Department, Lviv National Polytechnic University, 12 St. Bandera St., 79013 Lviv, Ukraine (e-mail: vdudykev@polynet.lviv.ua).

Iurii Garasym is with Information Security Department, Lviv National Polytechnic University, 12 St. Bandera St., 79013 Lviv, Ukraine (corresponding author to provide phone: +38 (096) 893-15-22, +38 (032) 235-77-49, +38 (032) 235-74-77, e-mail: garasym_yr@polynet.lviv.ua).

II. Information Security Systems with Survivability Property

Nowadays information security systems that are highly distributed improve the efficiency and effectiveness of organizations by permitting whole new levels of organizational integration. However, such integration is accompanied by elevated risks of intrusion and compromise. These risks can be mitigated by incorporating survivability capabilities into an organization's systems. As an emerging discipline, survivability builds on related fields of study (e.g., security, fault tolerance, safety, reliability, reuse, performance, verification, and testing) and introduces new concepts and principles. Survivability focuses on preserving essential services in security systems environments, even when systems in such environments are penetrated and compromised [5].

III. The Survivable Information Security Systems Definition

Information security system survivability – a security system property, which is the ability to store and carry their own set amount of target features (privacy of information, it's integrity, availability implementation) in the appropriate environment, taking into account various external and internal destabilizing factors (including threat models and the offender), which can lead to failures of its functional elements (nodes and/or communication channels) through appropriate changes in the structure and system behavior (which is based on the estimation of parameters of survival), while maintaining a minimum level as functioning according to the levels of degradation with the subsequent resumption of the preliminary effective operation for a preset time [6].

Thus, technical, software, information, methodological, linguistic and organizational support for security system should contain the following facilities, which would react to certain situations that lead to poor performance and preserve the system of information security.

Given the complexity survival security system to solve specific one-time events is impossible. Necessary is a continuous directed defined actions that would be carried out throughout the life cycle of ISS. Difficulty of ISS survivability properties due to embedded systems

complexity – the complexity of modern information systems designed to automate these processes.

Survival is complicated by the fact that in today's modern ISS may generate new features by itself that were not incorporated in the terms of reference or in the draft system, not to mention the inadequate reaction to the occurrence of various unpredictable situations [5].

IV. SURVIVABLE INFORMATION SECURITY SYSTEMS CHARACTERISTICS

A key characteristic of survivable security systems is their capability to deliver essential services in the face of attack, failure, or accident [7, 8]. Central to the delivery of essential services is the capability of a system to maintain essential properties (i.e., specified levels of integrity, confidentiality, performance, and other quality attributes) in the presence of attack, failure, or accident. Thus, it is important to define minimum levels of quality attributes that must be associated with essential services. For example, a launch of a missile by a ISS is no longer effective if the system performance is slowed to the point that the target is out of range before the system can launch [9].

These quality attributes are so important that definitions of survivability are often expressed in terms of maintaining a balance among multiple qualities attributes such as performance, security, reliability, availability, fault-tolerance, modifiability, and affordability. Quality attributes represent broad categories of related requirements, so a quality attribute may contain other quality attributes. For example, the security attribute traditionally includes the three attributes: confidentiality, integrity, and availability.

The capability to deliver essential services (and maintain the associated essential properties) must be sustained even if a significant portion of the system is incapacitated. Furthermore, this capability should not be dependent upon the survival of a specific information resource, computation, or communication link. In a military setting, essential services might be those required to maintain an overwhelming technical superiority, and essential properties may include integrity, confidentiality, and a level of performance sufficient to deliver results in less than one decision cycle of the enemy. In the public sector, a survivable financial system is one that maintains the integrity, confidentiality, and availability of essential information and financial services, even if particular nodes or communication links are incapacitated through intrusion or accident, and that recovers compromised information and services in a timely manner. The financial system's survivability might be judged by using a composite measure of the disruption of stock trades or bank transactions (i.e., a measure of the disruption of essential services).

Key to the concept of survivability, then, is identifying the essential services (and the essential properties that support them) within an operational system. Essential services are defined as the functions of the system that must be maintained when the environment is hostile or failures or accidents are detected that threaten the system.

There are typically many services that can be temporarily suspended when a system is dealing with an attack or other extraordinary environmental condition. Such a suspension can help isolate areas affected by an intrusion and free system resources to deal with its effects. The overall function of a system should adapt to preserve essential services [9].

It was linked the capability of a survivable system to fulfill its mission in a timely manner to its ability to deliver essential services in the presence of attack, accident, or failure. Ultimately, mission fulfillment must survive not any portion or component of the system. If an essential service is lost, it can be replaced by another service that supports mission fulfillment in a different but equivalent way. However, the identification and protection of essential services is an important part of a practical approach to building and analyzing survivable systems.

V. INFORMATION SECURITY SYSTEMS FEATURES

Today, security in one form or another is a requirement for an increasing number of embedded systems, ranging from low-end systems such as PDAs, wireless handsets, networked sensors, and smart cards, to high-end systems such as routers, gateways, firewalls, storage servers, and web servers. Technological advances that have spurred the development of these electronic systems have also ushered in seemingly parallel trends in the sophistication of security attacks. It has been observed that the cost of insecurity in electronic systems can be very high [1].

Describing ISS define the following characteristics: openness, concurrency, scalability, fault tolerance, transparency, community resources, complexity and unpredictability reaction to DF influences [5].

For such systems, there are several factors that are moving security considerations from a function-centric perspective into a system architecture design issue. For example [1]:

--an ever increasing range of attack techniques for breaking security such as software, physical and side-channel attacks require that the embedded system be secure even when it can be logically or physically accessed by malicious entities. Resistance to such attacks can be ensured only if built into the system architecture and implementation;

--the processing capabilities of many embedded systems are easily overwhelmed by the computational demands of security processing, leading to undesirable tradeoffs between security and cost, or security and performance;

--battery-driven systems and small form-factor devices such as PDAs, cell phones and networked sensors often operate under stringent resource constraints (limited battery,

storage and computation capacities). These constraints only worsen when the device is subject to the demands of security;

--embedded system architectures need to be flexible enough to support the rapid evolution of security mechanisms and standards;

new security objectives, such as denial of service and digital content protection, require a higher degree of co-operation between security experts and embedded system architects.

Information security systems in embedded systems consist of interrelated and interacting SE large number which can perform multiple functions, thereby increasing their sensitivity to the DF influences. These aspects unlike the branches of ships, aircraft and information systems design leads to a different survivability assessment approach [5].

VI. The Method Exploitation

The method is an engineering process that delivers an assessment of the survivability of current systems, proposed systems and modifications of existing ISS. This is a four-step process. *Step 1*, mission objectives and usage requirements for the security system are examined and the architecture is determined. *Step 2*, based on the mission objectives and failure consequences, the essential services (those services which must be survivable) and essential assets (those assets that must be maintained during an attack) are identified. Then usage scenarios are determined for the above based on how the business functions. The above are then combined and associated with the architecture of the ISS to define essential SE (ones that must be able to deliver the essential services and protect the essential assets during an attack). *Step 3*, intrusion scenarios are selected to determine the compromisable SE (the ones that can be penetrated). The final step is to determine the vulnerable SE of the architecture (the essential SE that are compromisable). *Step 4*, the SE are analyzed for the three key survivability properties of resistance, recognition and recovery. The deliverable is a Survivability Map, which is a chart associating all attack scenarios with the corresponding vulnerabilities to associate the current and recommended architecture strategies for resistance, recognition and recovery [9].

The above process is carried out by two teams, the company team (CT) and the outside security team (ST). The two teams interact through a series of meetings. The CT delivers the mission statement, business processes and system architecture to the ST. The ST then uses the information to determine the essential SE and reports it back to the CT. The ST then does the attack analysis and reports back the compromisable SE to the CT. Then the Survivability Map is determined by the ST and given to the CT.

The above process is not necessarily linear. Information can be revised at any joint meeting and the revisions used to update the results of any step. This is called a "spiral process" to point out that overall process can turn back on itself. Any step can be repeated and even at the end, the first step could be done again if new information is presented.

VII. Security System Degradation Levels

Analyzing ISS automated control system survivability it is established a connection between ISS automated control system degradation levels, ISS equipment and ISS degradation levels.

Information security systems in accordance with its parameters, management system state, equipment and its management system may be subjected to different functioning quality degradation levels (fig. 1).
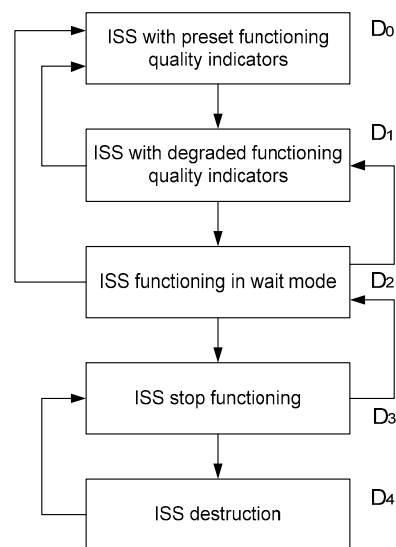
Fig. 1. Information security system functioning degradation levels

Information security system works with desired functioning quality indices both in stationary and instationary (extreme conditions) modes meets the requirements that apply to it, and is a zero level (Surv$\geq$0.7) of degradation (D_0).

On the first level of (D_1) information security system degradation (0.4$\leq$Surv<0.7) works with downgraded functioning quality indices and lower than the nominal output parameters. Transition on the first level of degradation can be caused by failures in the security system management, security system equipment, such equipment management system, and power requirements. Economic losses at this checkpoint are small. The period of stay at this level of degradation for ISS may be transient, sufficient to recover equipment that has denied. Then ISS returns to zero level of degradation.

Under certain conditions, ISS can switch to the second level (Surv<0.4) of degradation "idling" (D_2), that is casual security system disconnect from the electricity circuit. At the second level of degradation ISS can go from the zero or first level of degradation. An economic loss in the transition of ISS work is increasing. On the second level of degradation ISS may return to the first or zero level of degradation.

The ISS third level of degradation is the "stop" (D_3). The security system forced stop causing large economic losses. At this level of degradation ISS can go from any previously described levels of degradation.

At zero or first level of degradation for ISS may return through the implementation of the algorithm run.

Last, the fourth level of degradation (D_4), is a catastrophic state of ISS irreversible "destruction" (Surv=0). At this level economic losses reach considerable size, physical loss may be caused (ISS SE physical destruction, terrorist acts, etc.).

The security system transition from the work mode with desired functioning quality factors at the level of degradation is determined by changes in the security system parameters, ISS management degradation, ISS equipment and management system of this equipment, energy system state.

While security automated control system is investigating, determine the appropriate connectivity between security management system degradation levels and security system equipment with information security system, as a management object.

VIII. ISS Survivability Assessment Method

Structural elements states description [2]. Each SE is injected two logical variables: x_i – i-th element efficiency indicator ($x_i=1$, if it is efficient and $x_i=0$ otherwise), y_i – efficient element status ($y_i=1$, if the element is working, $y_i=0$ otherwise). The z_{ij} indicators are introduced to avoid the DF influence on functional elements:

$$z_i = V_{(j)} z_{ij},$$

where $z_{ij}=1$, if j-th type DF affects the i-th functional element, $z_{ij}=0$ otherwise. Now it is possible to express the structural elements state indicators:

$$u_{i0} = 1[e_0] = x_i y_i \overline{z}_i; \quad u_{i1} = 1[e_1] = x_i \overline{y}_i \overline{z}_i;$$

$$u_{i2} = 1[e_2] = \overline{x}_i \vee x_i z_i.$$

Setting logical dependencies. Logical equations for efficient element's unknown states are based on physical processes dynamic models preliminary analyses taking into account the actions of emergency protection, management and reconfiguration:

$$y_i = f_{y_i}(x_k, y_j, z_k, k = 1,...,N, j \in M_i), \quad (1)$$

$i=1,...,N$, where N – number of elements in the system, M_i – elements set which are adjacent to the i-th element. A set of

expressions as (1) creates a logical equations closed system representing in vector form as

$$Y = f_Y(X, Y, Z). \quad (2)$$

The advantage of this record is that for efficient element description are used only his immediate environment and not necessary to examine the entire system. Then more of these and rather simple dependencies efficient element explicit dependence of other elements and DF efficiency characteristics can be found using different mathematical methods. System efficiency is determined using its elements efficiencies and dependencies as (2). The main for many systems is a source elements relatively small group state. System efficiency is determined considering the state of all other elements, because of the indirect links that appear in (2). For the system which consist on one function efficiency logic functions write as

$$F = f(X, Y, Z). \quad (3)$$

As a multifunctional system dependence as (3) is written for each function separately. If it is necessary to simultaneously perform all functions, then

$$F = \&_{(i)} f_i(X, Y, Z). \quad (4)$$

where f_i – logical function $\&_{(i)}$ – i-th system feature indicator. The proposed method for system states describing does not require all elements states combinatorial enumeration. The f_i functions are logical equations formal systems.

Solving systems of logical equations. The equation system (2) is linear and can be brought to be the form:

$$y_i = a_i \vee a_{i1} y_1 \vee a_{i2} y_2 \vee ... \vee a_{iN} y_N, a_{ij} = 0, \quad (5)$$

where a_i and a_{ij} – factors that clearly expressed by x_i and z_i. There are different ways of logical equation systems solving including the determinants method, lookup method, matrix method etc. Solving (5) type Y=g_Y(X,Z) it is necessary to substitute in (3) or (4) and obtain an explicit expression

$$F = f(X, g_Y(X, Z), Z) = g(X, Z). \quad (6)$$

Note that the logical equation solution needs to be done many times: once for the basic structure of S_0, when all $z_{ij}=0$, and yet many times as there are different kinds of DF. In the end, turning over all kind of disturbances in single and multiple DF it is possible to get a full set of functioning institutions in the system. The (6) function admits, therefore, *d*-survivability and *m*-survivability analysis through sorting elements state vector.

Structural elements and external influence probabilistic description. Every ISS structural element that is presented in probabilistic model with probability $p_i=P(x_i=1)$ that element is efficient any moment. When DF is appear $z_{ij}=1$ then i-th element resistance to the j-th DF (DF for ECN ISS consider only from threats model) can be counted using a_{ij} probability that element maintain efficiency when there are DF influence. Besides set the probability of getting the element in the DF *j*-th factor sphere of influence.

Capacity function transformation to a form transition to replacement. It can be switched to distinguish the full or

partial replacement form. The full replacement forms are perfect disjunctive normal form (PDNF), form in basis "logical conjunction-negation" and orthogonal forms disjunction. After bringing to one of these forms it is possible to replace logical variables and logical operations on probability and arithmetic. It is possible to take the transition form to partial replacement if such transformations are difficult because of their complexity.

Mixed form notation. Replacing variables in irretrievable converted efficiency function is partial substitution which resulted in some variables and logical operations replace on probabilistic and arithmetic operations, other variables and operations are moving in the arithmetic expressions exponent. Received form is called mixed form because it contains both logical and probability variables, and two groups of operations: arithmetic and logical.

Survivability indicator definition. Using logical variables substitution procedure in mixed forms that are compiled for the S_0 basic structure and other efficient structures S_i it is possible to find $P(t/S_0)$ and $P(t/S_i)$ probability, then conditional survivability function $G_i(t)$. Next step – find survivability function, unconditional survivability function, average number of DF.

Enabling the integration between ISS SE after DF influence. In case of successful malicious attacks implementation occurs functioning quality degradation which causes denial of services, system losses, time delays, security service reduce – ISS resources lack situation. In this case it is necessary to estimate ISS survivability using streaming model. The results of it functioning enable efficient information flows redistribution between ISS SE. The challenge is to find the original graph collapse on p components probability; the edges (or vertices) existence probability; two graph peaks membership to one component probability; existence graph upper and lower probability limits, ribs of which exist with probability p [2]. Establishing contact with a given percentage of graph vertices after a single DF influence probability:

$$\beta = 1 - \exp\{-d\sum_{k=0}^{k_s-1}\frac{5^k}{k!}e^{-5}b\} \qquad (7)$$

vertices number remaining:

$$\sum_{k=1}^{k_s-1}g_k^l(\eta) \qquad (8)$$

where b – connection establishing probability for attacks density 100 per minute; certain graph peak defeat probability $\Delta/D=0.05$; $k_s=1$.

IX. Conclusion

The logic-probabilistic method in comparison with the exhaustive hypothesis search method and equivalent circuits method has the following advantages: simplicity, is subject to automation, used to analyze the survivability of not only systems with the same SE (as opposed to the exhaustive hypotheses method), accuracy and speed (unlike the equivalent schemes method), using streaming

survivability assessment model enables (quantitative) to communicate between ISS SE after DF influences and determine the ISS SE number which will remain after DB influences.

REFERENCES

[1] Kocher P. Security as a new dimension in embedded system design / P. Kocher, R. Lee, G. McGraw, A. Raghunathan, S. Ravi // Proceedings of the 41st annual Design Automation Conference. – 2004. – P. 753-760.

[2] Garasym I. Information security system survivability assessment method based on logical-probabilistic models / I. Garasym // Proceedings of the XIth International Conference CADSM 2011. – Polyana, Svalyava (Zakarpattya), Ukraine, 2011. – P. 160-161.

[3] Dudykevych V.B. System to protect information that tend to survivability. Concepts / V.B. Dudykevych, J.R. Garasym / / Scientific and technical journal "Modern information security," Special issue. 2010. № 4. P. 6-13 (in Ukrainian)

[4] Garasym J. Develop a model assessment of viability for information security systems // Computer Science and Engineering: Proceedings of the IV International Conference of Young Scientists CSE-2010. Lviv: Publishing House of Lviv Polytechnic National University, 2010. P. 320-321 (in Ukrainian)

[5] Dudykevych V. Survivable security Systems Analysis / V. Dudykevych, I. Garasym // Computer science and information technologies: Materials of the VIth International scientific and technical conference CSIT 2010. – Lviv : Publishing House Vezha&Co, 2010. – P. 108-110.

[6] Garasym J.R. Notion of survivability systems for information protected corporate networks / J.R. Garasym, V. Dudykevych // Proceedings of the Third International Scientific Conference "Information and Economic Security (INFECO-2010)". Kharkov, 2010. Issue 3 (84). P. 107-109.

[7] Ellison R. J. A Case Study in Survivable Network System Analysis / R. J. Ellison, R. C. Linger, T. Longstaff, N. R. Mead // CMU/SEI-98-TR-014, ESC-TR-98-014. – 1998. – P. 1-37.

[8] Ellison R. J. Survivable Network Systems: An Emerging Discipline / R. J. Ellison, D. A. Fisher, R. C. Linger, H. F. Lipson, T. Longstaff, N. R. Mead // CMU/SEI-97-TR-013, ESC-TR-97-013. – 1999. – P. 1-51.

[9] Dudykevych V.B. Behavior of protection under the influence of destabilizing factors / V.B. Dudykevych, J.R. Garasym // System analysis. Informatics. Management (SIAU 2011): Proc. of the II All-Ukrainian Scientific Conference. Kiev: CPU, 2011. P. 76-78.

Prof. Valeriy Dudykevych is Honored Inventor of Ukraine, a Head of West Regional Research-Scientific Information Security Center, a Head of the Information Security Department of Computer Technologies, Automation and Metrology Institute of Lviv Polytechnic National University.

Date of his birth is 23.11.1941, Lugansk (Ukraine).

Education and Degrees Received:

1963 – Speciality: "Electrical Appliances", Qualification: electrical engineer, Lviv Polytechnic Institute, Lviv (Ukraine);

1969 - 1971 – Ph.D. student, Lviv Polytechnic Institute, Lviv (Ukraine);

1971 – PhD in "Automatics and Telemechanic elements and devices", Lviv Polytechnic Institute, Lviv (Ukraine);

1973 – Associate Professor, Automation and Telemechanics Department, Lviv Polytechnic Institute, Lviv (Ukraine);

1991 – Doctor in "Devices and Methods of Measuring Electrical Quantities", Lviv Polytechnic State University (Kyiv, Ukraine);

1993 – Professor of Automation and Telemechanics Department, Lviv Polytechnic State University, Lviv (Ukraine);

1993 – Academician of International Academy of Computer Science and Systems;

1994 – Honored Inventor of Ukraine.

Professional Activity:

1963 - 1969 – Assistant, Automation and Telemechanics Department, Lviv Polytechnic Institute, Lviv (Ukraine);

1972 - 1976 – Assistant Dean of Automation Faculty, Lviv Polytechnic Institute, Lviv (Ukraine);

1992 - 2001 – Dean of Automation Faculty, Lviv Polytechnic National University, Lviv (Ukraine);

1993 – Head of Automation and Telemechanics Department, Professor, Lviv Polytechnic State University, Lviv (Ukraine);

2004 – Head of West Regional Research-Scientific Information Security Center, Lviv (Ukraine);

2006 - present – Head of Information Security Department, Professor, Lviv Polytechnic National University, Lviv (Ukraine).

Research interests are transducers frequency signals, the number-switching converters codes for measurement devices and control, medical instrumentation, test measurement systems, methods and techniques information protection.

More than 500 publications, including 2 textbooks, 187 patents, 1 glossary of information security, methodological manuals, scientific-research papers and conference proceedings.

Iurii Garasym is an Assistant of Information Security Department of Computer Technologies, Automation and Metrology Institute of Lviv Polytechnic National University.

Date of his birth is 11.08.1987, Lviv (Ukraine).

Education and Degrees Received:

2004 - 2009 – Master Degree in Information Security with limited access and automated processing, Lviv Polytechnic National University, Lviv (Ukraine);

2010 - present – Ph.D. student, Information Security Department, Lviv Polytechnic National University, Lviv (Ukraine).

Professional Activity:

2010 - present – Assistant, Information Security Department, Computer Technologies, Automation and Metrology Institute, Lviv Polytechnic National University, Lviv (Ukraine).

Research interests are secure enterprise communication networks, information security systems survivability, socio-technical security, information security systems audit.

More than 45 publications, including methodological manuals, scientific-research papers and conference proceedings.

Adjustable Output Voltage-Range and Slew-Rate Trapezoidal Waveform Generator with Harmonics-Reduction Ability

Mariusz Jankowski

Abstract— **The paper presents a circuit designed to provide trapezoidal output voltage signal, scalable in term of output voltage-range and slew-rate value. Additionally, the circuit is endowed with signal edge rounding functionality, realized by output voltage buffer itself. Schematics, way of operation, and simulation results are presented.**

Index Terms — **Trapezoidal waveform generator, voltage discriminator, slew-rate control, edge rounding.**

I. INTRODUCTION

ANALOG signal generation may be a complex task, depending on analog system requirements. Process of signal forming tends to be a multi-step operation due to special features imposed on the generated signal. On the other hand, complicated multi-stage signal forming circuitry imprints its own non-idealities into the resulting output signal.

Thus, it is good approach to reduce number of signal processing stage, e.g. by making them multi-role ones. One such solution is presented in the paper. The described circuit generates trapezoidal voltage signal with adjustable slew-rate and voltage-range. Such signals are used e.g. by wireless transmission systems, including automotive applications. Signal rounding enables avoiding of high frequency noise at the moments of rapid slew-rate value changes of transmitted signals. Such occurrence may violate transmission and EMC rules and eliminate circuit from commercial use.

II. CIRCUIT STRUCTURE OVERVIEW

The presented circuit consists of two main stages. The first one provides trapezoidal constant slew-rate voltage signal ranging from ground to supply voltage.

The following stage serves as: a buffer for current-mode output of the preceding stage, an output signal voltage-range limiter and edge-rounder. Fig. 1 presents general view of the circuit structure, with additional OPAMPs serving as sources of virtual ground and supply voltages.
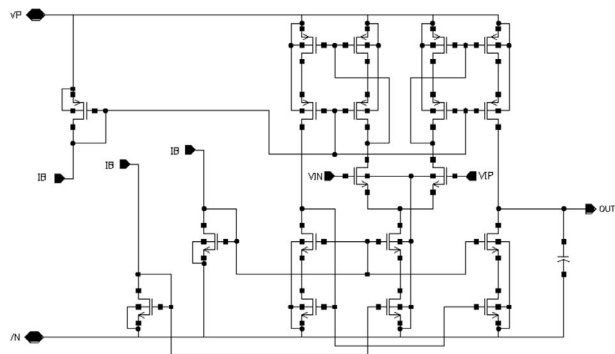
Fig. 1. General view of the waveform generator

III. TRAPEZOIDAL SIGNAL GENERATION

Trapezoidal signal generation used in the circuitry is based on principle of consecutive charging and discharging of capacitor with constant value currents. Such operation can be performed by a variety of circuits [1]. The commonly used structure is the output stage consisting of current mirrors and load capacitors.

Exemplary solutions are shown in paper [2]. One of them is just a kind of modified OTA circuit [4], presented in Fig. 2. It is equipped with two bias current inputs – one for general circuitry biasing and other for defining slew-rate value. Another solution presented in [2] consists of current mirrors and current-flow cutting switches.

In the solution presented in this paper a similar solution is used. The one difference is that the new generation stage utilizes current-flow bypassing switches, which do not force current-flow extinguishing process during switching, but just reroute it, additionally switching down inputs of corresponding mirror inputs (Fig. 3). Such approach makes the circuitry power consumption more stable.
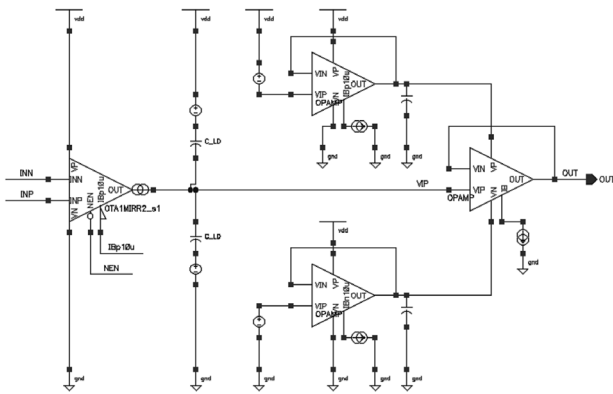
Fig. 2. Modified OTA serving as capacitor feeding circuitry
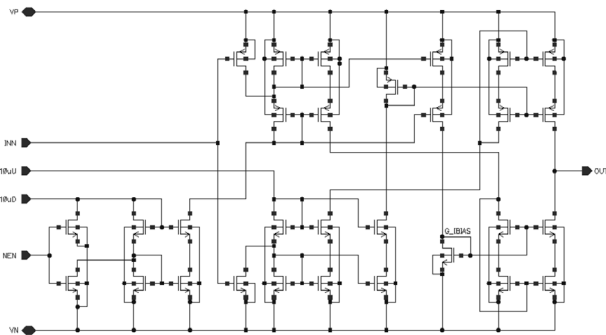
Fig. 3. Trapezoidal signal generation circuitry

Other modification is presence of two slew-rate defining inputs, which enables generation of non-symmetrical signal shapes like triangle or saw-tooth – like. The stability of slew-rate value of the output signal depends on output impedance of current mirrors utilized in the output stage as well as quality of available capacitors. In presented solution cascode mirrors are used. If higher quality output signal is required, regulated-cascode circuits can be used.

IV. Signal Rounding and Voltage-range Limitation

The signal rounding and voltage-range limiting procedures are in fact performed by one stage. The stage is a direct concatenation of two simple OPAMPs, one equipped with NMOS differential pair and one with PMOS differential pair. These OPAMPs are connected at inputs and output points.

In a way they form a kind of simple pseudo rail-to-rail OPAMP (Fig. 4), which is used as a simple non-inverting buffer. Another modification is power connection of the concatenated OPAMP to two voltage regulators, which provide virtual supply and ground voltages equal to limits that are to be imposed on the output voltage.

The virtual supply and ground regulators can be provided by quite simple OPAMP structures. Simple OPAMP solution presented in [3] and shown in Fig. 5, is enough for supplying the concatenated OPAMP due to its low power consumption level. Also simpler specialized solutions can be used, because full voltage-range operation of these

OPAMP voltage-regulators is not required in presented application.
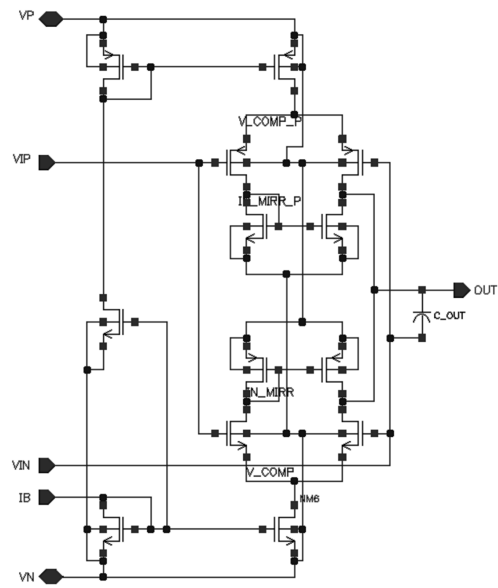
Fig. 4. Simple pseudo rail-to-rail OPAMP
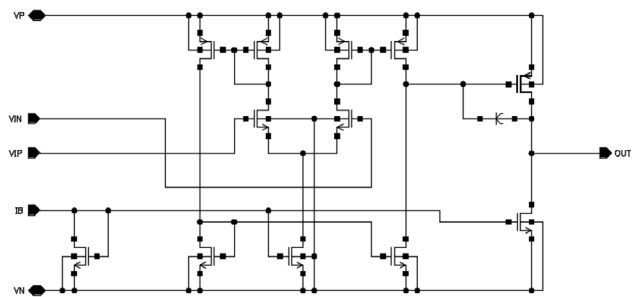
Fig. 5. Virtual ground and supply voltage-regulator

The voltage-limiting effect in the presented OPAMP is due to fact, that its input is fed with signal that over- and undershoots levels of, respectively, virtual supply and ground voltage. The input signal cannot pass supply voltage levels of the concatenated OPAMP and finally output signal stops following the input signal and stays blocked at virtual supply and ground levels.

Signal voltage rounding effect is achieved because when input voltage approaches one of virtual power levels, one of simple OPAMPs starts to gradually switch itself off, due to extinguishing of the current source that feeds OPAMP's differential pair. The distraction effect is deepened by input voltage to power voltage over- and undershoots. If these voltage level excesses are high enough, gradually more distorted output signal reaches level of virtual ground or virtual supply. The rounding effect is in fact a side effect related to non-ideal operation of simple OPAMPs inside the concatenated OPAMP.

Time domain simulation results are presented in Fig. 6. Output signals of both signal generation stages are shown.

The required rounding and voltage-range limiting functionality can be easily observed. It can be seen that the original trapezoidal signal also gets rounded but only when it reaches its maximum of minimum voltage level. When it leave its extreme voltage levels, no rounding happens.
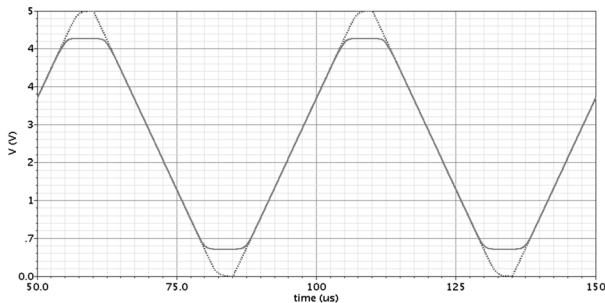
Fig. 6. Original (dotted line) and rounded (solid line) signal of the circuit

Fig. 7 shows first derivatives of the trapezoidal and rounded signal. It can be observed that the rounded signal is slightly deteriorated my means of slew-rate value. This phenomenon is related to fact that during operation of the concatenated OPAMP, its inside OPAMPs go off and on according to input voltage values, which influence the operating OPAMP part of the circuit. For numerous applications such signal behavior is acceptable, because it does not produce high frequency harmonics in rounded voltage signals. Critical points in original signal and their absence in the rounded signal can be observed in Fig. 8. It shows second derivatives of voltage signals.
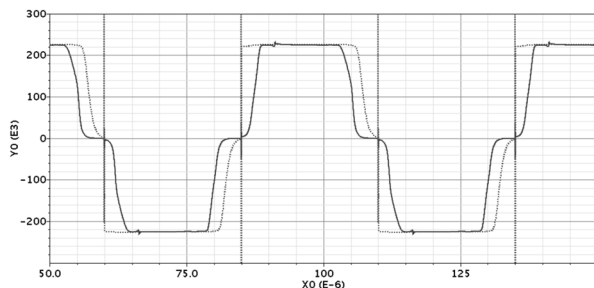
Fig. 7. Derivatives of original (dotted line) and rounded (solid line) signal of the circuit
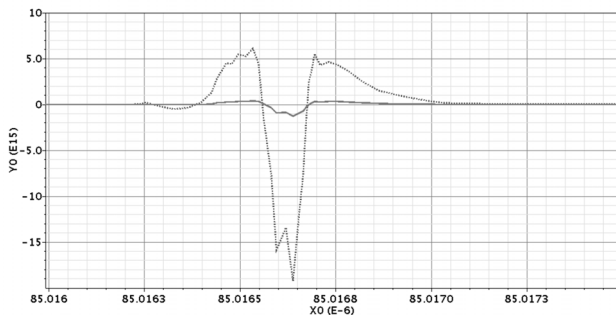
Fig. 8. Close-in view of derivatives of original (dotted line) and rounded (solid line) signals of the circuit
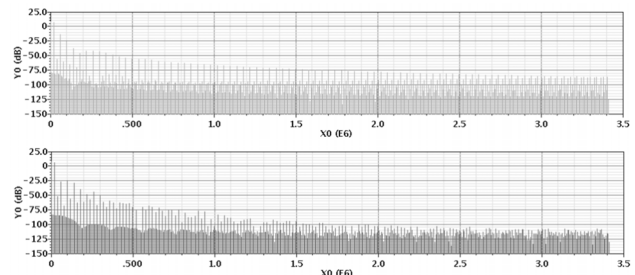
Fig. 9. DFTs of original (upper) and rounded (lower) generator signals

High value of second derivative marks time-points where high frequency harmonics in the voltage signals appear. It can be observed that maximum value of original signal second derivatives 15-20 time exceeds values observed for rounded signal.

Improvement in signal quality, understood as absence of high frequency incursions can be observed in the rounded output voltage signal.

More precise comparison of both signals is made my means of Discreet Fourier Transform (Fig. 9). The figure shows lower level of harmonics for the rounded signal.

V. Conclusion

The presented circuit shows simple but way of producing limited voltage-range regulated slew-rate trapezoidal signal generator equipped with signal rounding ability.

Structure of the proposed circuit is simple and consists of only two modules due to making them a multi-role blocks.

References

[1] United States Patent 5025172, "Clock generator generating trapezoidal waveform," Issued on June 18, 1991.

[2] M. Jankowski, "Adjustable Output Voltage-Range Trapezoidal Waveform Generator with Harmonics-Reduction Functionality," International Conference TCSET'2008, Lviv-Slavsko, Ukraine, February, 19-23, 2008.

[3] M. Jankowski, "Trapezoidal Waveform Generation Circuit with Adjustable Output Voltage Range," International Conference CADSM'2007, Polyana, Ukraine, February, 20-24, 2007.

[4] R. J. Baker, "Cmos: Circuit Design, Layout, and Simulatiofn, 2nd Edition", Wiley-IEEE Press, November 2004.

Mariusz Jankowski received the M.Sc. and Ph.D. degrees in electronics engineering from the Technical university of Lodz, Lodz, Poland, in 1998 and 2003, respectively.

He is an Assistant Professor with the Department of Microelectronics and Computer Science at Technical University of Lodz, Poland. His research interests include analysis and design of mixed signal integrated circuits, including high-voltage applications, design of integrated 3D circuits, at present he works on 3D circuits and EMC issues. He is the author or coauthor of more than 30 publications, including two chapters in books.

Research and Development of Methods and Algorithms Non-hierarchical Clustering

Yuri Stekh, Mykhaylo Lobur, Vitalij Artsibasov

Abstract – **Researched and developed the methods and non-hierarchical clustering algorithms for determining the optimal initial number of clusters without any background information on the location of the clusters. The methods and algorithms are researched in the famous test set Iris.**

Index Terms—**Non-hierarchical clastering, initial number of clusters, clustering algorithms library, clustering algorithms testing.**

I. INTRODUCTION

THE issue of clustering is one of the fundamental tasks in Data Mining, Web Mining, Text Mining, machine learning [2,5,6]. The main task of clustering is to partition a given set of images into classes (clusters) that allow you to explore the similarities and differences between the images in the clusters and make sound conclusions about the images that belong to certain clusters. In clustering process is not any information about the predefined classes. And therefore the process of clustering refers to the problems of unsupervised learning. The result of clustering depends on several factors that determine of which is a method and a clustering algorithm, the initial parameters of clustering algorithm. The main steps in the process of clustering are shown in Fig. 1.
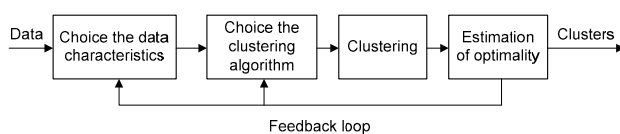
Fig. 1. The main steps of the clustering process

Yuri Stekh is with the Lviv Polytechnic National University, Ukraine (e-mail: stekh@polynet.lviv.ua).

Mykhajlo Lobur is with the Lviv Polytechnic National University, Ukraine (e-mail: mlobur@polynet.lviv.ua).

Vitalij Artsibasov is with the Lviv Polytechnic National University, Ukraine (e-mail: free_2@list.ru).

At the stage of feature selection of images the feature vectors of images are generated that best reflect the properties of objects that are clustered. At the selection stage of clustering algorithm will be selected one of the algorithms contained in the library of algorithms for clustering. This stage involves the selection of a similarity measure of images in the cluster and the clustering criteria. Similarity measure is set as the basis of the rules for inclusion of the image to a particular cluster. Clustering criterion determines the stop of clustering algorithm. At the stage of clustering is clustering a given set of images with chosen algorithm for the chosen degree of similarity criteria and clustering.

In the evaluation of clustering results assesses the optimality of the partition a given set of images into clusters. At this stage are used some precise and / or approximate optimality criteria. Therefore, finding an optimal partitioning into clusters requires the construction and study of ensemble methods and algorithms for clustering and application of several criteria for optimality of the partition into clusters.

II. FORMAL PROBLEM STATEMENT

Let $D = \{\overline{X}_1, \overline{X}_2, ..., \overline{X}_n\}$ - a set of n images, each of which has d attributes. Let $L = \{A_1, A_2, ..., A_m\}$ - a set of algorithms for clustering. Each clustering algorithm A_i generates a partition for a given set D into clusters $P^{(i)} = \{S_1^{(i)}, S_2^{(i)}, ... S_m^{(i)}\}$. Let $S = \bigcup_{i=1}^{m} P^{(i)}$ is set of all clusters, which received with a set of algorithms L. The aim of the ensemble methods and algorithms is to obtain the optimal partition into clusters corresponding to the optimal maximum or minimum value of the optimality criteria $T = \{C_1, C_2, ... C_k\}$. The elements of T must satisfy the following properties:

- Each cluster must have at least one image $C_i \neq \varnothing$ $\forall i \in \{1, 2, ..., k\}$
- Each image must belong to at least one cluster $C_i \cap C_j = \varnothing$ $\forall i \neq j, i, j = \{1, 2, ..., k\}$
- All images must be separated by cluster $\bigcup_{i=1}^{k} C_i = P$

Thus, the clustering problem is reduced to an optimization problem that requires research and development of ensemble methods and algorithms, and study certain criterion functions.

III. ANALYSIS OF KNOW SOLUTIONS TO THE PROBLEM

Well-known clustering algorithms can be divided into hierarchical and nonhierarchical [2,6]. In hierarchical clustering algorithm refuse to determine the number of clusters. Instead, it builds a tree of nested clusters (dendrogram). Problems such algorithms are well known: the choice of measure of the closeness of clusters, the problem of the inverted index in dendrogram, the inflexibility of the hierarchical clustering.

In non-hierarchical clustering algorithms, the nature of their work and conditions of the stop must be set in advance using the input parameters of the algorithm. The most important of these is the number of desired clusters.

IV. DEVELOPMENT OF METHODS AND ALGORITHM FOR NON-HIERARCHICAL CLUSTERING

Solving the problem of optimal choice of the initial number of clusters is proposed to resolve through the development of ensemble methods and algorithms for non-hierarchical clustering. The overall design and the use of algorithms are shown in Fig. 2.
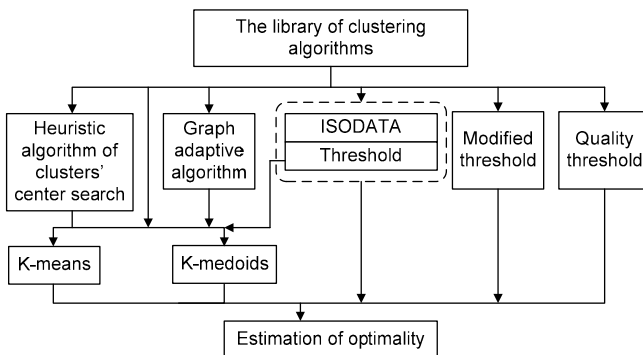
Fig. 2. The overall design and the use of algorithms

The main feature of the developed non-hierarchical clustering algorithms library is that the problem of choosing the number of clusters is solved by using two algorithms: a heuristic search algorithm of the cluster centers and cluster centers of the search algorithm using a neural network [7]. Heuristic search algorithm of the cluster centers (HSACC) is designed to find cluster centers in a given set of images without any background information on the location of the cluster centers. The algorithm is implemented in two versions. The first modification finds the most distant point of each cluster centers. After finding the centers of the clusters remaining images are distributed in clusters on the criterion of minimum Euclidean distance to cluster centers.

Let $\overline{X} = \{\overline{x}_1, \overline{x}_2, ..., \overline{x}_n\}$ - a set of points of images, $\overline{Z} = \{\overline{z}_1, \overline{z}_2, ..., \overline{z}_n\}$ - the desired cluster centers.

Step 1. Select randomly the center point of the first cluster k.

Step 2. $\overline{z}_1 = \overline{x}_k, l = n - 1$

Step 3. Compute the Euclidean distance from the remaining points of the set of images to the center of the first cluster
$$D_{i1} = \| \overline{x}_i - \overline{z}_1 \|, i = 1(1)l$$

Step 4. $K_i^{(1)} = \max_i \{D_{i1}\}, L_1 = K_i^{(1)}, p = i$

Step 5. Select the center of the second cluster $\overline{z}_2 = \overline{x}_p, l = l - 1$

Step 6. Compute the Euclidean distance from the remaining points of the set of images to the center of the first and second clusters
$$D_{i1} = \| \overline{x}_i - \overline{z}_1 \|, D_{i2} = \| \overline{x}_i - \overline{z}_2 \|, i = 1(1)l$$

Step 7. $A_i = \min_i \{D_{i1}, D_{i2}\}$

Step 8. $K_i^{(2)} = \max_i \{D_{i1}, D_{i2}\}, L_2 = K_i^{(2)}, p = i$

Step 9. If $L_2 > S \cdot L_1$ then $\overline{z}_3 = \overline{x}_p, l = l - 1$, else STOP.

Step 10. Compute $L_{c.a.} = \dfrac{L_1 + L_2}{2}$.

Step 11. Compute the Euclidean distance from the remaining points of the set of images to the center of the first, second and third clusters: $D_{i1} = \| \overline{x}_i - \overline{z}_1 \|$ $D_{i2} = \| \overline{x}_i - \overline{z}_2 \|$, $D_{i3} = \| \overline{x}_i - \overline{z}_3 \|, i = 1(1)l$.

Step 12. Compute $A_i = \min_i \{D_{i1}, D_{i2}, D_{i3}\}, i = 1(1)l$.

Step 13. Compute $K_i^{(3)} = \max_i \{A_i\}, L_3 = K_i^{(3)}, p = i$.

Step 14. If $L_3 > S \cdot L_{c.a.}$ then $\overline{z}_4 = \overline{x}_p, l = l - 1$, else STOP;
$\overline{x}_i \in A_k$ if $\| \overline{x}_i - \overline{z}_k \| < \| \overline{x}_i - \overline{z}_r \|, r = 1(1)l, m \neq k$

The parameter S is chosen within $S \in (0,1)$.

Such a construction algorithm finds the most distant centers of the clusters, does not always lead to optimal outcome. Therefore the second modification was originally defined by the geometric center point set of images.

$$\overline{x}_c = \frac{1}{|D|} \sum_{i=1}^{n} \overline{x}_i \qquad (1)$$

where $|D|$ - cardinality of point set images.

The point of the first cluster center is chosen as the most distant point on $\overline{x}_c$. In many cases, this allows us to determine more optimal centers of the clusters. An alternative method of finding the initial cluster centers in the developed ensemble methods and algorithms is proposed in [7] algorithm for finding the cluster centers by graph algorithm. In this algorithm, investigated a set of

points be represented by a full connected undirected graph , where each image is associated with node. Thus the investigated set of points in the images of d-dimensional space turn into a complete undirected weighted graph.

The algorithm works in such a way that the nodes, that are on the border of the cluster region, transmit their activity to the nodes, located within the regions of clusters. The learning process of the complete undirected weighted graph converges to such a result, when in each cluster region is only one active neuron - the center of the cluster. This approach to finding the cluster centers can continue to use well-known algorithms for k-means and k-medoids [4,6], without specifying the initial parameters for them. Library of algorithms includes the well known threshold algorithm [4]. The main drawback of this algorithm is that it requires setting a threshold T and the output of this algorithm depends on the choice of starting point – the first cluster center. As a result, the algorithm can form a series of clusters that give the section of clustering regions and require additional heuristics to determine to which cluster belongs the point of images. The library including our modified threshold algorithm (Fig.3).

$$D_{i1} = \| \bar{x}_i - \bar{z}_1 \|$$
$$D_{i1} < T \rightarrow \bar{x}_i \in K_1$$
$$\bar{z}_2 = \frac{1}{n} \sum_{i=1}^{n} \bar{x}_i$$
$$\| \bar{z}_{i+1} - z_i \| \le \varepsilon$$

A_i – Datapoints set in the cluster K_i
B_o – Initial set of datapoins
$$B_{i+1} = B_i \setminus A_i$$
$$B_{i+1} = \varnothing \rightarrow STOP$$
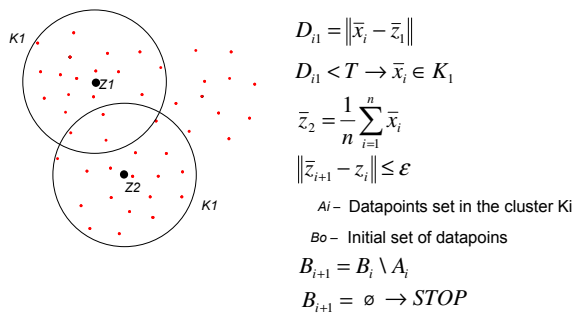
Fig. 3. The modified threshold algorithm

This algorithm is a combination of classical threshold algorithm and k-means. Feature designed combination is that, unlike the threshold algorithm, in each area of clustering first calculated the geometric center of the set of images and the set of images of this area later excluded from consideration as the next cluster. The clustering process continues until we obtain an empty set of image points.

It is developed improved quality threshold algorithm. This algorithm represents an improvement in the modified threshold algorithm (Fig. 4).

In this algorithm first the clusters for each image of a given set is computed with steps of a modified threshold.algorithm. The number of points of the images in each field are computed. As the first cluster are taking the region with the highest number of points of images. This set of points is eliminated from further consideration. This iterative process continues until we obtain an empty set of points in the images. This algorithm has the highest complexity among all algorithms library. The developed algorithms and combinations of algorithms were tested on a known test set Iris [5]. The results of the test are reported in Table 1.

B_o – Initial set of datapoins
$$|B_0| = m$$
$$K_1 = n_1, K_2 = n_2, ..., K_m = n_m$$
$$g_i = \max_i (n_1, n_2, ..., n_m)$$
K_i – First cluster
$$B_1 = B_0 \setminus K_i$$
$$B_{p+1} = B_p \setminus K_i$$
$$B_{p+1} = \varnothing \rightarrow STOP$$
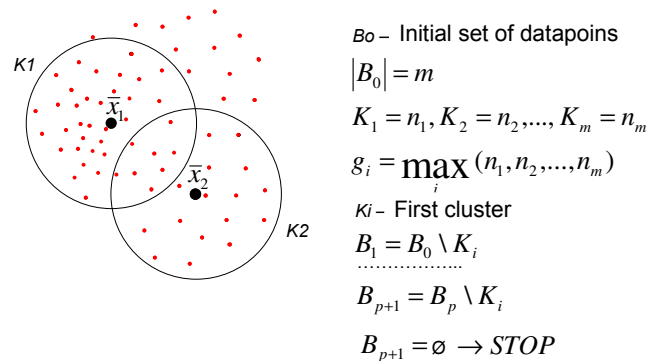
Fig. 4. The improved quality threshold algorithm

TABLE I
THE RESULTS OF THE ALGORITHMS WORK TEST

Results / Distance function	Algo-rithm	Percent of wrong cluste-red points (%)	Duration of algorithm work (ms)	Mean size of cluster	Mean distance between clusters	Mean distance between cluster centers
Euclidian	K-means	14,67	6419	0,9212	3,473	3,366
	HSACC+ K-maens	16	3510	0,9183	3,487	3,4
	HSACC+ K-medoids	16	2787	0,9183	3,487	3,433
Square Euclidean	K-means	12	2694	1,099	12,33	11,13 3
	HSACC+ K-means	20	3026	1,068	14,6	13,76 6
	HSACC+ K-medoids	20	2797	1,068	14,6	13,66 6
Powered (p=4, r=2)	K-means	10,67	3273	0,7582	9,159	8,433
	HSACC+ K-means	20	4072	0,7431	10,77	10
	HSACC+ K-medoids	17,33	2276	0,7425	10,6	10,46 6

V. CONCLUSION

Devepoled methods and algorithms for non-hierarchical clustering. Developed a software library that allows to find the optimal partition into clusters using computing clusters with different algorithms with different initial parameters and by computing the criterial functions such as the average

intercluster distance, the average size of the cluster and the average distance between the centers of the clusters.

REFERENCES

[1] Barseghyan A.A, Kupriyanov M.S, Stepanenko V.V., Kholod I.I. Models and methods of data analysis: OLAP and Data Mining.- Petersburg: BHV - Petersburg, 2004. 236 p. (in Russian)

[2] Barseghyan A.A., Kupriyanov M.S, Stepanenko V.V., Kholod I.I. Technology of data analysis: Data Mining, Visual Mining, Text Mining, OLAP. SPb.: BHV - Petersburg, 2007. 384 p. (in Russian)

[3] Kim Dzh.-O., Myuller C.W., Klekka W.R. Factorial, discriminant and cluster analysis. Per. from English. Moscow: Finances and Statistics, 1989. 215 p. (in Russian)

[4] Tu J., Gonzales R. Principles of pattern recognition, 1978. 411 p.

[5] Classification and cluster / J. Van Rayzin. New York. 389 p.

[6] A. J. Jain, M. N. Murty, P.J. Flynn "Data clustering: a review" *ACM Computing Surveys, v..31, pp. 264-323, 1999.*

[7] I. Farmaga, P. Shmigelskyi, P. Spiewak, L. Ciupinski. Evaluation of Computational Complexity of Finite Element Analysis // IEEE CADSM'2011. – Polyana, 2011. – PP. 213 - 214.

[8] Stekh Y., M.E. Faisal Sardis, Lobur M.V., Kernytskyy A.B. Algorithm for finding the optimal number of clusters // Bulletin of the National University "Lviv Polytechnic". № 651. P.129-132. 2009 (in Ukrainian)

Dr. Stekh Yuri, PhD, Assistant Professor of CAD department of Lviv Polytechnic National University. Research interests: databases and artificial intelligence methods for CAD tools for microelectronic devices design, Data Mining.

Prof. Mykhaylo Lobur, DSc, PhD, Academitian of Academy of Science in applied radioelectronics, Head of CAD department of Lviv Polytechnic National University, Director of LRERI. Research interests: design of CAD tools for microelectronic devices design.

Vitalij Artsibasov Master of Computer Science. Research interests: artificial intelligence, Data Mining.

Adaptive Navigation Interface Powered by Evolutionary Algorithm

Taras Filatov, Viktor Popov, Ievgen Sakalo

Abstract — **A combination of adaptive navigational interface and real time collaborative feedback analysis for documents relevance weighting is proposed as an viable alternative to prevailing 'telegraphic' approach in information retrieval systems. Adaptive navigation is provided through a dynamic links panel controlled by an evolutionary algorithm. Documents relevance is initially established with standard information retrieval techniques and is further refined in real time through interaction of users with the system. Introduced concepts of multidimensional Knowledge Map and Weighted Point of Interest allow finding relevant documents and users with common interests through a trivial calculation. Browsing search approach, the ability of the algorithm to adapt navigation to users interests, collaborative refinement and the self-organizing features of the system are the main factors making such architecture effective in various fields where non-structured knowledge shall be represented to the users.**

Index Terms — **evolutionary, adaptive, navigation, web, collaborative, social, interface, information retrieval, knowledge, document, algorithm, adaptive, refinement, text.**

I. INTRODUCTION

In the world where indexing approach and linguistic search prevail the habits of search and location of required information are well established. According to Meadow [19], there are four different types of search which are:

1) known-item search (looking for a specific source where desired information is known to be stored);

2) specific-information search (looking for a specific information, the goal of the search can be formulated);

3) general-information search (goal exists but is hard to formulate, "I know when I see it");

4) searching to explore the database (goal not specified, users wants to get familiar with the knowledge corpus).

From the point of view of implementation in knowledge acquisition and representation systems, there are basically two known approaches of how users are allowed to perform their searches:

a) indexing, employed in the state-of-the-art search engines, where users have to type in key phrases i.e. they have to formulate their request linguistically, in a 'telegraphic' way;

b) browsing, employed in end web sites, knowledge bases, documents collections, directories, where users have to navigate through massive hierarchy in order to find the information they want;

The first approach is being used for indexing of the whole internet in the state-of-the-art search engines. The main advantage of this approach is full automation as it is designed for indexing huge amounts of text documents available in the internet. The disadvantages are those that are caused by automation and working on a global scale. Firstly, the problems of text understanding and natural language processing are one of the most challenging in Artificial Intelligence field and still remain without an efficient solution. Adjacent are the problems of classification and relevance calculation, the so-called 'web clustering' problem [2]. Secondly, there is a limit in complexity of the algorithms. The latest Information Retrieval (IR) methods can not be applied on a full scale as there always should be a compromise between speed and accuracy of indexing. Despite all the disadvantages, the indexing approach prevails and serves especially well for the known-item and specific-information search types.

The second approach is being used where manual indexing is possible. The advantage is that users get ready-to-use taxonomy i.e. structured navigation for the documents corpus. Such index is usually more accurate and understandable for users. The disadvantages are that the amount of human labor required to create and maintain such index grows in a progression with the growth of the corpus. The possibility for human errors is also present. The main disadvantage for users is usually slow updating. It is more likely that automated crawler will spot new or updated documents faster than human operator. For the explorative tasks ('general-information search', 'searching to explore the database'), however, the browsing approach of organizing the navigation is by no means the best solution. Obviously, when the user is driven by the third type of search ("I know it when I see it"), numerous factors, coming from the organization of navigation and semantic links in the particular knowledge representation system, play role varying the chances for the user to get the desired information.

It can be concluded therefore that the general-information search is presently the one which is less supported by knowledge acquisition and representation

systems while it still remains to be one of the natural ways of searching the information.

It is logical to suppose that there could be hybrid solutions employing the advantages of different approaches in order to serve the needs of such users better. E.g., browsing approach to navigation could be combined with automated indexing. It would be possible to use the latest IR and Data Mining approaches in order to refine results and propose most relevant documents using the adaptation to current user's needs and other users' feedback.

Despite the demand in such applications seems to be high, there are no well known hybrid solutions to be applied widely. We believe this is due to the fact that such systems are of a more complex nature and there was no right solution yet proposed.

The idea of automated and user-oriented data pre-processing solutions for web is not novel. A number of systems were developed to organize the information requested by users into semantic data collections [1, 15, 17, 24, 27] which makes it more convenient to browse and search for related documents. In these cases, however, users need to know (or predict) the wording that is used in the documents they are looking for in order to specify a search query to be passed to the search engine. On the other hand, in some systems users are faced with knowledge base with a host of categories which may make the search confusing. We believe it is better to propose a random set of documents initially; this set to be of proportional size to the navigational panels most web surfers are used to; then make the system gradually recognize users' interests and modify the set correspondingly. Resembling approach was presented in [28] where a method for dynamic link generation is proposed. The online module, however, was not developed. No means for automated data collection have been though of. In addition, there is no mechanism mentioned to remember user so each time the user is new to the system which reduces the possibilities for analysis and adaptation. The mechanism for links fetching is not presented in detail, and no ultimate algorithm is proposed.

The main obstacle, we may assume, for the further development and implementation of such systems is the involvement of technologies from various fields. It is necessary to provide a solution for automated data collection, data storage, compression and retrieval, user identification, user-system and user-user interaction, information retrieval, documents analysis, relevance calculation, adaptation, access patterns analysis etc. That is why the successful researches in this field are limited.

There are, however, few researches that have achieved to present systems of such scale. As a typical representative we will briefly overview the multi-agent collaborative Web mining system [9]. Authors position their system as a tool for web content mining and post-retrieval analysis. System employs multi agent structure and provides strong collaborative functionality allowing users to re-use the results of searches performed by other users. The shortcomings of the system, from our point of view, are the following. First, special software is required to use the

system. It would be logical to suppose that it is more convenient for the user to use a standard web browser and surf the internet in a standard way while the assistant system should be represented by an interface occupying just small part of the screen. Second go related issues of users' identification and calculation of relevance between users and documents. Users which start to use the system are required to register and specify their topic of interest. The web 2.0 and social web trends of nowadays which promote usability and ease of use make internet surfers choose systems which are able to identify them automatically and adapt to their needs during the interaction. We believe a collaborative information retrieval system could work with a minimal user input while taking maximum from users trivial browsing interactions. Regarding the relevance calculation, in the system proposed by Chau et al [9] there is no mathematical model to calculate the relevance between users and documents. There is a concept of 'Knowledge dashboard' where the links found by the users researching the same area appear. What is going to happen when user has multiple areas of interest? What if users change their mind and get interested in other topic? What if there are more related links than there could be displayed at one screen? How to weight the similarity of interests between users, the relevance of pages and the actuality of the information for the user? The multi-agent collaborative Web mining system is a significant achievement however it does not give answers to these questions. The issue of data storage goes adjacent with the data processing and calculation. We believe a method can be found to map the documents of the corpus into a single multidimensional space which will enable trivial mathematical calculations to be used to resolve some of the abovementioned questions.

II MAIN PRINCIPLES

These are the main principles we have followed when creating our system:

1. Data preparation and relevance calculation. Unstructured data from given sources may be refined using the Information Retrieval techniques in order to provide the system with the preliminary understanding of the knowledge corpus. State of the art techniques may also be used to calculate the relevance of documents in real time mode.

2. Adaptive interaction. We propose a system for interaction based on evolutionary algorithm powered navigational panel with features of adaptation to current user behavior and needs.

3. Further refinement through users feedback. In the system proposed certain weights and features as well as additional interfaces correspond to social factor making use of users interaction in order to improve the service. i.e. users help the system to understand better the taxonomy of the knowledge it possesses.

4. Collaborative factor. The system proposed learns through the history of interaction the interests of users and is then able:

a) to propose relevant documents based on previous interests indicated by the user;

b) to match users by interests and suggest documents the user might be interested in, by using the research carried out by other users with similar interests.

III THE SYSTEM

A. Data acquisition

The data acquisition does not lie within a focus of the current paper and therefore we will mention it briefly here. For our experimental implementation we have created a typical search engine-like system for the purpose of data collection and preprocessing. The system consists of a data collection and processing module that crawls and indexes the documents available via HTTP protocol (i.e. web pages) starting with the given start pages and limiting the crawler to stay within the given domains. The documents are then processed through Porter's stemming algorithm [23] and the stop words filter and are reproduced as vectors using the tf.idf metrics. [25, 26] To minimize the calculation time the vector space is reduced using the linear dimensionality reduction techniques such as Principal Component Analysis (PCA) which are known to give better results for such data [18]. The process of calculating the intrinsic dimensionality of the corpus precedes the actual dimensionality reduction stage which improves the efficiency of the mapping. The relevance between the documents established using the *Knowledge Map* compressed to the intrinsic dimensionality of the corpus has sometimes turned out to be closer to the real, actually known, relevance, than the same calculated using the uncompressed corpus during our experiments (more details in chapter 4 below). A detailed description of data acquisition and storage used in our system starting from searching and indexing techniques to comparison of various dimensionality reduction methods would be out of scope of the current paper as here we focus on the innovative parts of evolutionary navigation so only the key principles of data acquisition part are explained. It is important to add however that PCA has been chosen as it returned the most stable variance of results when evaluated through relevance comparison with the known data. Also important is the fact the PCA itself enables calculation of the intrinsic dimensionality [10]. The procession of mapping or scaling is the final stage in the data acquisition part of processes in our system. The obtained multidimensional vector space is used as a *Knowledge Map* for the corpus of indexed documents and the Euclidian distance between the vectors of corresponding documents is used as a metric for relevance. Further justification of the method is given in chapter 4 where the results of experiment are provided.

B. Interface

In pursuit of the task of creating a hybrid solution serving the needs of users motivated by 'general information search' we have learned that one of the most important initial tasks was to create a proper interface layout. After

the study of research works devoted to human-computer interaction and usability, few key principles have been outlined which have formed the interface of our experimental model. It is known [12, 13, 21] that navigation area should be a compact block, which is possible to overview with a single eye movement. Human brain is able to keep track of a limited number of objects, according to studies [3]. The navigational panel should not change its location and remain at the same place, closer to the top of the page [4, 6, 7, 13]. Placing the panel in the left side of the screen results in better performance and improved navigation times [5, 14, 16]. Following these principles we have designed the layout for the interface of our system (figure 1).
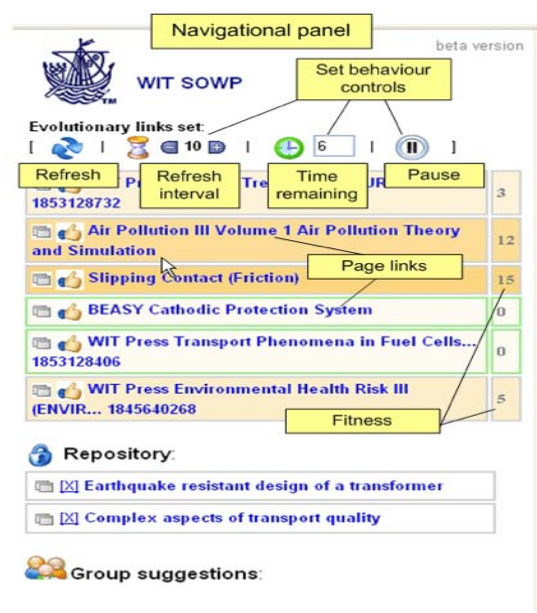
Fig. 1. Navigational panel interface. Implementation

The content area of the web browser has been divided in two vertical column frames. The first, leftmost frame, is of fixed width and contains the navigational panel. The remaining space is a content area. Navigational panel remains at its place all the time. It is powered by our system. The content area displays different web pages chosen by user with the help of the navigation panel. The interface of the navigational panel consists of the following elements:

'Refresh' button will stop the process of evolution in the Set and fill it with random, zero fitness pages.

'Refresh interval' controls allow to adjust the time between iterations of the process of evolution of the Set.

'Time remaining' control allows user to see how much time in seconds is left before the Set will update itself and the following iteration of the evolution will occur.

'Pause' button allows to 'freeze' the process of evolution so that the Set remains in the same condition if the user wants so.

The Set itself consists of a fixed number of elements representing the pages indexed by the system. Each element consists of:

'Open in a new window' button which opens the page in a new window.

'Add to Favorites' button saves the page to Favorites section.

'Page link' is a title of the page linked to the page itself. When clicked, it opens the page contents in the content area.

'Fitness' column displays the value of the current page's fitness calculated by the evolutionary algorithm powering the Set.

'Favorites' is a section where pages are saved by the user. While the Set contents are being changed over time according to algorithm, the 'Favorites' section remains stable so that user is able to save interesting pages there.

'Social suggestions' is a section which is, again, controlled by the algorithm. The system calculates which of the other users have similar interests and displays the pages from their 'Favorites' in this section.

IV INTERACTIVE PART

A. The Set

Following our interface specification, we have a navigational panel of a limited size Set_{size} (7 to 10 items in our experiments, in accordance to [3]). Our aim is to use this limited area in a best way to provide users with relevant results.

In case the user hasn't visited the system before and hasn't made any action in the system yet there is simply no data for the system to analyze user's interests.

Therefore, following our browsing approach, the system has to give the user something to start with. As much topics as possible should be proposed within the given limited items number and due to this limitation it would be logical to present the most unrelated links.

Let's divide the *Knowledge Map* into Set_{size} number of clusters and pop out a random link from each of the clusters. Let's introduce the *random_links_show* function to be used when system knows nothing about current user:

random_links_show()

$$ClusterN_{size} = \frac{KnowledgeMap_{size}}{Set_{size}}$$

for N = 1 to Set_{size}
{
   linkN = random(ClusterN)
}

In case there is no response from the user after some time R (response time), it is likely that user is not interested in the topics proposed, in which case the process is repeated and new random links are proposed. It will however look more natural and psychologically easier to perceive for the user if we replace a small number of links and leave others. [8, 11]

$$Links_{replace} = const$$

$$Links_{replace} \ll Set_{size}$$

In our experimental implementation a default value for $Links_{replace}$ has been set to 3.

Thus at each iteration we will replace *links_replace* number of random links from the set with new links according to random_link_show() function.

The algorithm for set renewal will therefore look as following:

random_links_show()

$$ClusterN_{size} = \frac{KnowledgeMap_{size}}{Set_{size}}$$

LR_{array} = { select $Links_{replace}$ number of random id's from the Set }

for N = 1 to Set_{size}
{
  if linkN $\notin LR_{array}$
  {
    linkN = random(ClusterN)
  }
}

This way our algorithm becomes evolutionary and *links_replace* provides a mechanism for recombination. The algorithm renews itself in time trying to display the most scarcely distributed topics from the corpus and in such way tries to invite user for interaction.

When user is interested in a certain topic, he/she will choose the corresponding link. The system has to use this important information. After first interaction of such kind has occurred, the stage of adaptation and supervised learning begins. The system has to adapt to current users needs and also learn better the characteristics of current user and also the characteristics of knowledge corpus (using the feedback received as interaction from current user).We will now introduce an *interactive_iteration*() function which in contrast to *random_links_show* will take into account the user's feedback, current Set contents and previously collected data.

We need somehow to distinguish the links the user is interested in from links for which user has shown no interest. Let's introduce a traditional parameter of evolutionary algorithms, the fitness, into our system. Let's make it that when the user clicks a link, the fitness of the corresponding link will increase at $fitness_{click\_modifier}$ value: $fitness_{click\_modifier}$ const

In our experiments the $\text{fitness}_{\text{click\_modifier}}$ has been equal to Set_{size}.

Let's also state that links with positive fitness remain in the Set and the recombination rule (links_replace in *random_links_show()* function) applies only to those links with minimal or zero fitness, e.g. now the less fit, not random, links will be replaced. This will give users time to study properly the selected links and will also allow further adaptation and complex evolution schemes.

To emulate the natural processes of distraction and vaporization of interest and also to anticipate the moment when the user wants to switch to other topic we will penalize the positive fitness with time. Let's therefore during each minimal time interval (*ageing_interval*) decrease the fitness of all links with positive fitness by 1.

```
ageing_interval const
 ageing_interval << refresh_interval
```

```
ageing()
      if (ageing_interval)
       {
         for N = 1 to Setsize
     {
        linkN fitness = linkN fitness −1
     }
         }
```

To adapt to user's needs let's also compliment our algorithm with another function in addition to *random_links_show*. Would be logical after a certain time of interaction for a system to adapt and make it so that new emerging links are not random but most relevant to the topic the user is currently interested in. We can assume that links with positive fitness represent current user's interest with a certain degree of accuracy. We describe the improved algorithm after we introduce a mechanism of Favorites below.

We add a mechanism of Favorites for two reasons:

1) Users convenience so that they may store links of current interest in a separate place where links are not subject to ageing and will therefore not disappear until user decides to remove them manually.

2) 'Favorites' mechanism is also very important information used by system for learning and adaptation as it represents a confirmed expression of user's interest.

Let's allow Favorites influent the evolution process as if they were present in the links set and had comparatively high ranks

$$\text{Favorites}_{\text{fitness}} = \max(\text{Favorites}_{\text{fitness\_const}}, 2*$$

$$\max(\text{Link1}_{\text{fitness}}, ..., \text{LinkN}_{\text{fitness}}))$$

In our experimental implementation we set

$\text{Favorites}_{\text{fitness\_const}}$ to 50.

This will allow users control the process of evolution better by adding and removing links from Favorites.

As there could be more than one link with positive fit in the Set, here opens a unique possibility for a user to express their interest in different, even not related topics within the corpus. Our system should make use of it and try to find documents simultaneously related to all the topics of interest.

Operating with multidimensional space of our *Knowledge Map* we may assume that point laying at equal distance from the points of all of the links with positive fitness will represent the centre of interest.

In order to consider the different level of interest of different links let's move the coordinates of this point of interest closer to those points corresponding to links with higher fitness. We therefore will establish the coordinates for *Weighted Point of Interest* (*WPI*).

The function to calculate the *WPI* for the current user is given below.

Calculate_WPI(current user)

```
 for D = 1 to KnowledgeMapdimensionality
  for N = 1 to Setsize
     WPIcoordD =  WPIcoordD +
                 + LinkNcoord[D] * LinkN fitness
  for F = 1 to Favoritessize
     WPIcoordD = WPIcoordD +
                 + LinkFcoord[D] * LinkFfitness
```

$$\text{WPIcoord}_D = $$

$$= \frac{\text{WPIcoord}_D}{\text{Set}_{\text{size}} + \text{Favorites}_{\text{size}} + \sum_{M=1..N} \text{LinkM}_{\text{fitness}} + \sum_{G=1..F} \text{LinkG}_{\text{fitness}}}$$

Having established the coordinates of WPI we will assume this is a central point of interest of the user and the most relevant documents will have a minimal Euclidian distance to that point. Thus, if there are links with positive fitness in the set or there are links in Favorites we replace the random function with the function of relevance:

```
    if positive fitness
      link[N] = most_relevant (WPI)
    else
      link[N] = random (cluster[N])
```

Where most_relevant() function basically represents choosing a document in the collection with the closest Euclidian coordinates to those of the WPI.

B. Mulation

It is difficult for the system to determine when user changes her mind and is not interested in the topic anymore. Two mechanisms help to deal with such situation:

a) Ageing - with time the fitness of all links in the set will come to zero and the system will return to the initial stage with random links.

b) Reset control – special control in the navigational panel which allows user to reset (fill the set with random, zero ranked links) to the initial state at any time.

These mechanisms, however, won't help to construct complex search requests as once user expresses her interest in one topic, the system gets oriented at that topic only. The new emerging links will be related to that single topic and the possibility to research related and unrelated topics simultaneously in order to make use of WPI mechanism becomes obscured.

That makes reasonable for us to introduce another traditional element of evolutionary algorithms which is mutation.

We adjust the algorithm so that even when there are positive fitness links in the Set and there are links in the Favorites repository, still there is a probability for the random link to appear.

Let's introduce the parameter which will determine with what probability the emerging links will undergo mutation.

$$Mutation_{probability} = const$$

In our experimental implementation we set $Mutation_{probability}$ to 0.3 which has been approved by the experiments to be an optimal value.

$interactive\_iteration()$

$$ClusterN_{size} = \frac{KnowledgeMap_{size}}{Set_{size}}$$

for N = 1 to set_size

if (random(0..1) $\leq Mutation_{probability}$) then
linkN = random(ClusterN)

User identification and authentication mechanism is not a subject of this paper and may be realized using traditional mechanisms widely applied in client server applications. We have initially realized the user identification in our experimental system through login-password authentication combined with the mechanism of sessions. This authentication mechanism has been later replaced with the mechanism of cookies. The latter approach is better for research and evaluation purposes as users do not have to log in, which simplifies the work with the system. In applied implementations the authentication would be most likely handled by externals mechanisms as such system as described in this work would be integrated with existing user bases e.g. Facebook Social Graph.

In order to propose a broader variety of links to choose for the user it would be better not to display the links which have been already shown recently. We can see here it is necessary for the system to remember the history of what it had shown to the user and when:

history_links(user_id, link_id, timestamp)

We may also record for how long and which links have been present in the Favorites. These links are confirmed to be interesting for the user. The more they stay in the Favorites the more interesting and relevant they tend to be for the user. Our system should therefore record this data and use it for Social suggestions mechanism to share the experience of the current user with other users of the system.

Therefore, let's introduce a parameter *time_alive*, reflecting user's interest in particular link expressed by the time it has been stored in the Favorites:

favorites_history(user_id, link_id, time_alive, timestamp)
Time_alive will increment while link stays in the Favorites. *Timestamp* will store the system's date and time when the record is updated.

As user may not always pay attention to the system while it is evolving and history is still being recorded, this may cause the system to collect wrong data presuming user is still proactive. We propose to introduce a concept of Dormant mode. This mode will activate when user makes no actions in the system during *dormant_count* seconds.
It would be logical to vary the dormant count depending on the size of the document the user is currently reading and also on individual user's characteristics that reflect his/her level of activity within the system. Such calculations will increase the complexity of the system therefore in current implementation we propose a constant value for *dormant_count*:

dormant_count = const

In our experimental implementation the *dormant_count* parameter has been set to 300.

In turn, this will stop the incrementing of *time_alive* which should also be reflected in our algorithm. Let's also penalize the *time_alive* gained by links staying in Favorites during the time of inactivity:

if inactive time > dormant_count
then
  dormant_mode = on
  for all link_id in Favorites
    users_interests(interest_level) =
    =users_interests(interest_level) - dormant_count

The system stores the history of using the Favorites mechanism for each user. This data may be mined to extract useful knowledge about the interests of particular users and interchange information between users that seem to have similar interests. This will enable indirect collaboration

between the users of the system as new users may follow the successful searches performed previously by other users and therefore get to study the required topic in a faster and deeper way. [22] There are two directions here for the refinement of results using data mining approach:

1. To understand the current topic of interest of the user.

2. To find users with similar interests and fetch the links they have found useful.

In our system the user may indicate his/her interest in the link by clicking its title in the Set. After such an action the link will gain the positive rank and will remain in the Set so that the user has time to study the document. This will also attract other related documents into the Set. The user may however decide after having examined the document that the link is irrelevant to their search. Thus we cannot use the history of interim interactions in the Set as indication of users interests. The mechanism of Favorites is a more trustworthy source of such information, as the links in the Favorites are added manually by users and therefore are confirmed to be of interest.

To understand the current topic of interest of the user we may use two sources:
the actual data i.e. links present in the Favorites now
the history record of Favorites

In order to give user more control over Social suggestions mechanism, let's implement two modes determining the source to be used in order to establish the topic of interest:

a) when there are no links in the Favorites, the interests of the current user are determined using the history of the Favorites (if the number of records is > 0)

b) when there are links in the Favorites, the history is not taken into account and the Social suggestions are based on what is present in the Favorites at the current moment.
The following data format is being logged:

favorites_history(user_id, link_id, time_alive, timestamp)

The important parameters are *time_alive* and *timestamp*. *Time_alive* gives us information on how the user has estimated the importance of the link. Different users may have different activity level, the speed of reading, searching/browsing habits etc. Let's normalize *time_alive* parameter for each link by setting a maximum *time_alive* of any link stored by current user during all the time to 1 and finding a proportional value for each link:

$$\text{LinkF}_{\text{timealive\_modifier}} = \frac{\text{LinkF}_{\text{timealive}}}{\max_{N=1..F} \text{LinkN}_{\text{timealive}}}$$

Where F is an identifier of the link stored in Favorites history of the current user.

Timestamp allows us to penalize the old history following the assumption that old interests are less actual. We introduce a modifier value (a multiplier of link

importance), which will be near to 1 for newest links and near to 0 for oldest links.

$$\text{LinkF}_{\text{age\_modifier}} = \frac{\text{LinkF}_{\text{timestamp}}}{\text{NOW}() - T_0}$$

where T_0 is the timestamp of the oldest link (first link added to Favorites by the current user), NOW() is the timestamp of the current moment and $\text{LinkF}_{\text{timestamp}}$ is the timestamp of the moment when the history record of the link F has been updated.

Using either a) or b) approach let's establish the Weighted Point of Interest (WPI) using either links actually present in Favorites or normalized history data:

$$
\begin{aligned}
&\text{if } F > 0 \\
&\{ \\
&\quad \text{For } D = 1 .. \text{KnowledgeMap}_{\text{dimensionality}} \\
&\quad\quad \{ \\
&\quad\quad\quad \text{WPI(social)}_{\text{coord}[D]} = \\
&\quad\quad\quad = \sum_{N=1..\text{Favorites}_{\text{size}}} \frac{\text{linkN}_{\text{coord}[D]}}{N} \\
&\quad\quad \} \\
&\} \\
&\text{else} \\
&\{ \\
&\quad \text{For } D = 1 .. \text{KnowledgeMap}_{\text{dimensionality}} \\
&\quad\quad \{ \\
&\quad \text{WPI(social)}_{\text{coord}[D]} = \\
&= (\sum_{F=1..\text{History}_{\text{size}}} \text{LinkF}_{\text{timealive\_modifier}} * \\
&\quad * \text{LinkF}_{\text{age\_modifier}} * \text{LinkF}_{\text{coordD}}) / \\
&/ \sum_{F=1..\text{History}_{\text{size}}} \text{LinkF}_{\text{timealive\_modifier}} * \text{LinkF}_{\text{age\_modifier}} \\
&\quad\quad \} \\
&\} \\
\end{aligned}
$$

We need now to find users who match current user with their interests. It is obvious that in order to make such calculation, the system should store the actual WPIs i.e. the normalized coordinates of interest for each user. The coefficients for normalization are the following:

– Time (1 = most recent, 0 = the oldest record);

– Time spent in the Favorites (1 = the longest, 0 = the shortest). Before comparison the values for each user should be normalized so that 1 is the link which has spent the longest time in the Favorites of the certain user and 0 is the link with the shortest time spent in the Favorites of the certain user.

The WPI coordinates normalized by the abovementioned parameters ideally represent the current interest of the user. These values, recalculated periodically, should be stored in a separate database record for each user to enable fast real

time calculation for the social suggestions and other algorithms.

Back to our social suggestions algorithm, let's calculate the level of interest of each page for the current user.

For N = 1 to Pages_{total} (N $\notin$ Favorites)
{
  For U = 1 to Users_{total}
  {
    $\text{PageN}_{LOI} = \text{PageN}_{LOI} + \text{LOI\_modifier}_{N,U}$
  }
}

Where Users_{total} is the number of users in the database.

Pages_{total} is the number of pages in the database.

$\text{LOI\_modifier}_{N,U}$ is a coefficient reflecting how the level of interest of the certain document N for the certain user U should affect the level of interest of the same document for the current user. This value is a multiply of the following coefficients:

1) Time (1 = most recent, 0 = the oldest record);

2) Time spent in the Favorites of the user U (1 = the longest, 0 = the shortest), normalized;

3) Distance. Euclidian distance between the WPI of the current user and the WPI of user U.

$$\text{LOI\_modifier}_{N,U} = \text{Time}_{N,U} *$$
$$* \text{Time\_alive}_{N,U} * \text{Distance}(\text{WPI}_{current\_user}, \text{WPI}_{U})$$

The simple algorithm listed above will summarize the level of interest for each page as it should be for the current user taking into account both the active feedback of the other users (pages placed in Favorites) and passive feedback (time spent by the pages in the Favorites excluding 'dormant' periods, number of users suggesting the same page, the percentage of matching interests between the current user and the suggesting users, the overall levels of activity of the suggesting users, comparative novice of the information etc).

C. Final algorithm

Let us now conclude with a final algorithm for the functionality of our system. We propose two flowchart illustrations for the algorithm of the described system (figure 2). The first flowchart represents periodical process maintaining the system which is initialized every minimal period of time (1 second):
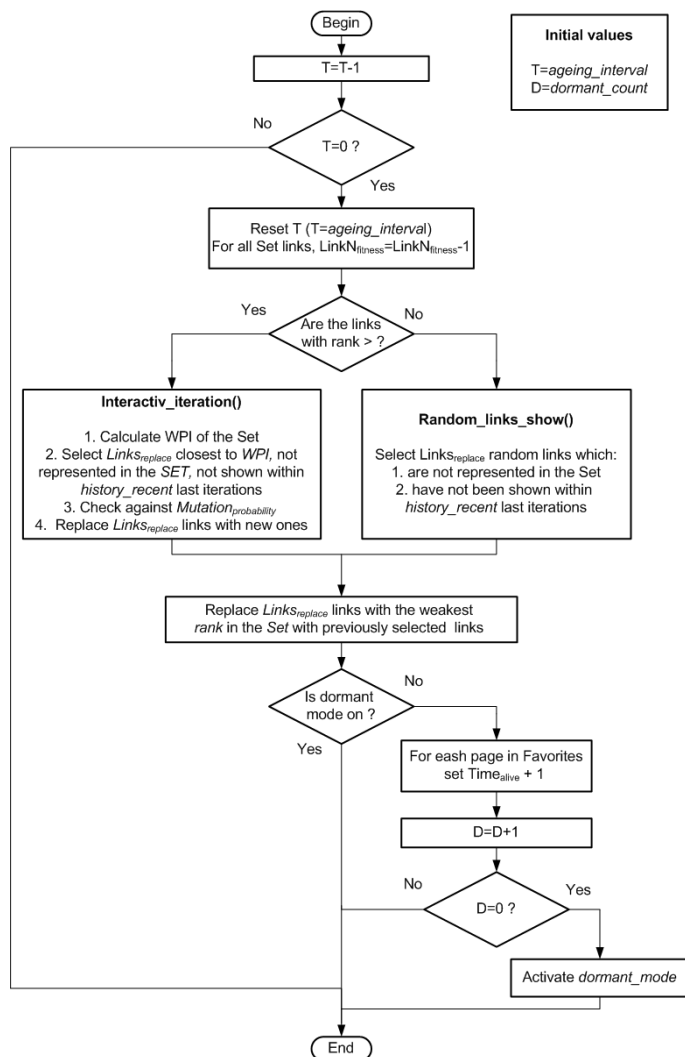
Fig. 2. Periodic automatically launched algorithm

The second flowchart represents algorithm of system decisions when user is taking some action (figure 3).

V. EXPERIMENT

Current experiment has been conducted in order to evaluate our proposed data collection and processing architecture which involves converting documents corpus into vector space via tf.idf metrics methodology and then compressing the vector space representation with the help of dimensionality reduction techniques. The purpose of such processing was to:

1. Allow the system establish initial categorization of the corpus by achieving mathematically computable vector representations of all documents via tf.idf metric.

2. Allow the system to perform complex real-time calculations during each iteration comparing relevance between numerous documents in the corpus and taking into account. This has been achieved through significant minimization of feature set (vector size) with

dimensionality reduction technique, PCA in current implementation.
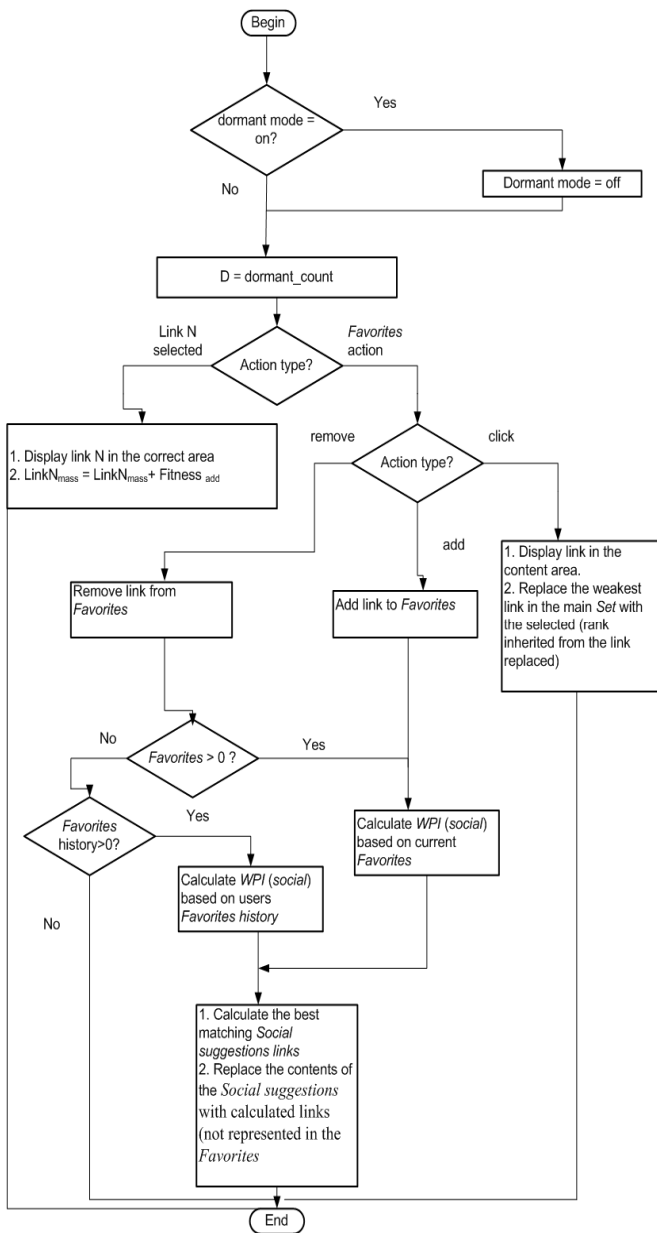
Fig. 3. User's action algorithm

For the purpose of evaluation of the approach, an extensive survey has been conducted where users have been continuously asked to evaluate the relevance between two random documents of the corpus and then the obtained relevance matrix has been compared to automated evaluations of the system with different parameters (no dimensionality reduction and various dimensionality reduction techniques with different parameters applied).

As a data source, the web site of our Wessex Institute of Technology has been indexed with a limit of 3000 pages.

The vocabulary of unique keywords, after stemming and stop words filtering obtained a size of 3897.

There have been conducted a survey in order to collect users' evaluation of relevance between 15 pre-selected pages in the corpus of documents used for evaluation in current work. 37 users with various level of knowledge in the area have left 352 opinions.

The correlation between relevancies reflected by Euclidian distances in SOM mappings and average pair wise relevancies obtained from survey results have been calculated. For comparison, in similar way correlation between SOM mappings and initial vector space distances have been also estimated. For comparison with other dimensionality reduction methods, Principal Component Analysis (PCA), Local Tangent Space Analysis (LTSA) and Stochastic Proximity Embedding (SPE) have been used. We list the results here in Table 1, techniques with different parameters given in the order of their performance.

Table 1. Various techniques compared with survey data

Technique	Dimensionality	Correlation with survey data
PCA optimal	19	0,445237453946
Initial tf.idf vectors	3897	0,42717044595324
SPE 3d	3	0,368396030076
PCA 2d	2	0,356945818598
SPE 2d	2	0,354836285591
PCA 3d	3	0,35202141743
SOM 3d 10x10x10	3	0,309568117231
SOM 3d 5x5x5	3	0,267381854644
SOM 2d 40x40	2	0,254117116968
LTSA 3d	3	0,15592757837
SOM 2d 20x20	2	0,128857727323
SOM 3d 15x15x15	3	0,0744928015985
LTSA 2d	2	-0,0116113046364

The results for discrete SOM measurements with various parameters for 2 and 3 dimensions in comparison to initial tf.idf and continuous (1-36 dimensions) measurements of PCA are graphically represented at figure 4:
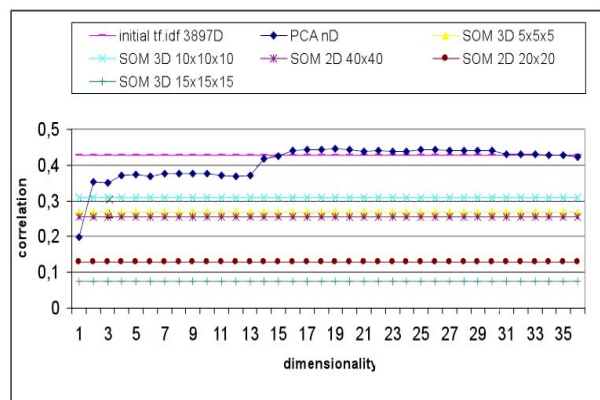

Fig. 4. Mapping comparison chart

It can be seen from results that best performance on correlation is given by high-dimensional mappings: initial

vectors (3897 dimensions) and PCA (best result in 19 dimensions). However from the point of view of visualization such high-dimensional data is of no use. The results in 2d and 3d are quite comparative for all techniques.

It is obvious from the chart at Figure 1 that at 2-3 dimensional level a linear dimensionality reduction technique (PCA) does not outperform SOM significantly. For clarity at the chart given we use continuous lines for initial vectors and SOM despite their values correspond to dimensions 2 and 3 only. We can also see from results that both linear (PCA) and non-linear (SPE) are applicable and provide good results. The exception is LTSA giving poor results, which is to testify that tangent spaces analysis is not a successful approach in such a case.

It is interesting that optimal PCA outperforms even initial tf.idf data. It is out of scope of current work to establish whether this is fortuitousness or is it an evidence of the fact that during the process of mapping an optimal representational space have been found and the features have been automatically discovered which are optimal from the point of view of relevance calculation. In such case it would be possible to use dimensionality reduction as a complementary technique to tf.idf to extract most representative features of the corpus and establish unified mapping for all the documents. However the latter is only applicable on condition that the intrinsic dimensionality of the manifold in corpus data is determined which is presently a challenging task.

Comparing SOM with other techniques at dimensions 2 and 3 we can see that the performance is slightly lower than PCA and SPE still it is comparable and correlation remains at 'positive medium' level which demonstrates a strong dependency with commonsense estimation.

VI CONCLUSIONS AND EXPERIMENT

A. Experiment

By no means the described experiment should be considered as an ultimate comparison of the techniques. The goal of the experiment has not been to find the best universal dimensionality reduction technique for the information retrieval data in general but to study the behavior of these techniques and different approaches in an existing real-world situation where the accuracy of knowledge representation provided by the implemented system significantly depends on the possibility of the compressed addressing space to keep the useful features of the original space and when such estimations given by the system could be compared to 'common sense' evaluations given by human users with average – above average level of knowledge of the field. It is important to understand that in other initial conditions – different knowledge topic, data corpus, configuration of dimensionality reduction algorithms we could have obtained the very different results. As an example of how important the configuration

is, the results of SOM techniques could be taken. The experiment has shown a strong influence of SOM configuration, in particular, dimensionality, on its performance. Thus, 3d SOM outperforms 2d SOM even when the number of neurons is lesser (40x40 performance still lower than 5x5x5). At the same time SOM 15x15x15 performs very poorly witnessing that the dependence is non-linear. These facts prove that configuration and architecture is very important for the performance of dimensionality reduction techniques implementations and researchers should experiment with different parameters (in case with SOM, such parameters are: dimensionality, number of neurons, topology, neighborhood radius etc) in order to find the most effective configuration. Still the experiment allows us to conclude with the following general findings:

– The correlation of relevance calculated using uncompressed tf.idf method with users opinions data is medium positive (42%).

– The correlation of the idem space compressed through selected dimensionality reduction method (PCA) remains medium positive and estimates 35-44% therefore making such processing worthwhile in order to reduce calculations during real-time evaluations of relevance in the system.

There are other advantages of the implementation of the dimensionality reduction stage being useful in prospective:

– Out-of-sample selection is supported i.e. when a web page is added to the collection, the neural network saved in the database is able to determine a best location for a new coming document in the existing mapping space, there is no need to restart the mapping or re-index the pages.

– Upon such requirements it is possible to map initial data into either discreet (integer) or continuous space. In first case SOM technique should be used. In case continuous mapping space is required, standard techniques such as PCA should be used.

It is also interesting that an issue of intrinsic dimensionality is being broached by the experiment. The task of finding intrinsic dimensionality is still non-trivial for IR field. Otherwise it would have been possible to theorize regarding extraction of optimal relevance distinguishing features of the corpus. An evidence for that at particular dimensionality PCA outperforms even initial tf.idf data.

B. Conclusios

In the current work we explicitly describe the algorithms powering the system of collaborative study of web documents. The main advantages of the system proposed compared to modern search engines and knowledge base interfaces are the following:

1) Browsing approach. Using browsing rather than indexing approach we provide users with a more natural way of locating required documents. The user always has a fixed number of links to choose from and by clicking the most relevant ones he/she is able to reach the targeted documents. In such case it is not necessary for a user to know the title of the document or any key phrases as the browsing is being done following the contextual relevance

chains. In many cases this approach is more beneficial than linguistic search through indexing as applied in modern search engines.

2) Intelligent evolutionary algorithm powered navigation. With the help of evolutionary algorithm it is possible to use a single navigational panel of a limited size to display links to all the documents in the corpus. It is an important advantage of the system that no manual pre-processing and categorization of documents corpus is required. System establishes initial relevance structure automatically and then refines it studying the documents access patterns of all users. The panel is dynamic and links to be shown are filtered according to latest real-time knowledge available to the system and previous interests expressed by current user.

3) Homogenous *Knowledge Map* space allowing simple mathematical calculations of the contextual relevance between documents. In our system each document obtains its coordinate in multidimensional space using the tdf.if metrics [26]. It is then possible to find out relevance by calculating the Euclidian distance between two certain documents. Moreover, it is possible to build complex requests 'find document Z which is relevant to X and 3 times more relevant to Y". Finally, the *Knowledge Map* concept allows easy mathematical representation of the current and previous interests of a certain user, which is called a *Weighted Point of Interest* (*WPI*) in our system. All the abovementioned parameters are used widely in the presented algorithms. To enable real time calculations we have proposed, implemented and evaluated through experiment the dimensionality reduction approach.

4) Social suggestions. The history of confirmed interests (*Favorites* mechanism) is being stored for each user. This and other individual parameters are normalized during calculations. The *dormant mode* feature tracks the periods of inactivity. The abovementioned *WPI* method allows real time calculation of current user's interests and those of other users. In combination these allow finding the documents which should be of most interest for the current user, based on data mining performed automatically by other users while interacting with the system.

The experimental implementation of the system has proven the applicability of the proposed combination of algorithms and methods. The results of users survey display good correlation of automated estimations with human common-sense estimations.

The main aim of our work was to propose a systematized method to be used in the industry of search, information retrieval and knowledge representation. Further research and improvements as well as practical applications are encouraged. The possible fields of application vary widely, from traditional web search where the system could be used to refine results to topic oriented knowledge bases for communities of experts or self organized web portals. Due to its browsing approach, high level of user-adaptability and some innovative features such as *Knowledge Map*, the system might find successful applications in many fields linked with data processing, either on its own or in combination with existing systems and methods.

Further work possibilities are broad. The necessity in certain improvements and modifications may vary depending on current implementation and application field. These are the major points in our method which could be improved, worked on or modified depending on application, as from our point of view:

– Evaluate different implementations and variations of td.idf metrics for *Knowledge Map* generation;

– Consider alternative (to tf.idf metrics) methods for *Knowledge Map* generation. Evaluate application of text recognition, ontology models and other alternative approaches (on their own or in combination);

– Further evaluate different dimensionality reduction methods for the *Knowledge Map* space, implement automated intrinsic dimensionality calculation, study the effects in relevance calculation improvements;

– Evaluate different clustering methods for documents coordinates in the *Knowledge Map* space;

– Evaluate the option of introducing clustering for users into groups of interests.

The other area for improvements in the implementation is interface. Compared to our experimental implementation we expect the versions applied to real world problems to have multiple improvements in terms of interface design and usability as well of code optimization making it more convenient for the users to use the system and easier for the server to handle substantial loads.

REFERENCES

[1] F. Abbatista, A. Paradiso, G. Semerano, F. Zambetta, An agent that learns to support users of a Web site. Applied Soft Computing, 4 (2004) 1-12.

[2] J. Allan et al, Challenges in information retrieval and language modeling: report of a workshop held at the center for intelligent information retrieval, University of Massachusetts Amherst, September 2002, ACM SIGIR Forum 37 (1) (2003) 31-47.

[3] G.A. Alvarez, S.L. Franconeri,. How many objects can you track?: Evidence for a resource-limited attentive tracking mechanism, Journal of Vision, 7(13):14 (2007) 1-10. Retrieved August 2008, from http://www.journalofvision.org/7/13/14/

[4] A.N. Badre, Shaping Web Usability: Interaction Design in Context, Addison Wesley Professional, Boston, MA, 2002.

[5] M. Bernard, Examining User Expectations for the Location of Common E-Commerce Web Objects, Usability News, 4(1) (2002). Retrieved July 2008, from http://www.surl.org/usabilitynews/41/web_object-ecom.asp

[6] M. Bernard, S. Hull and D. Drake, Where should you put the links? A Comparison of Four Locations. Usability News, 3 (2) (2001). Retrieved July 2008, from http://www.surl.org/usabilitynews/32/links.asp

[7] M. Bernard, L. Larsen, What is the best layout for multiple-column Web pages? Usability News, 3 (2) (2001) Retrieved July 2008, from http://www.surl.org/usabilitynews/32/layout.asp

[8] M. D. Byrne, J.R. Anderson, S. Douglass and M. Matessa (1999). Eye tracking the visual search of click-down menus, In: Proc. CHI'99, pp. 402-409.

[9] M. Chau, D. Zeng, H. Chen, M. Huang, D. Hendriawan, Design and evaluation of a multi-agent collaborative Web mining system, Decision Support Systems: Web retrieval and mining, 35 (1) (2003), 167-183.

[10] S. Cheng, Y. Wang, Z. Wu, Provable Dimension Detection using Principal Component Analysis, In: Proc. 21st annual symposium on Computational geometry, Pisa, Italy, 2005, pp. 208-217.

[11] B.D. Ehret, Learning where to look: Location learning in graphical user interfaces, In: Conf. Proc. CHI 2002, pp. 211-218.

[12] D.K. Farkas, J.B. Farkas, Guidelines for designing web navigation. Technical Communication, 47(3) (2000) 341-358.

[13] A.J. Hornof, T. Halverson, Cognitive strategies and eye movements for searching hierarchical computer displays, In: Conf. Proc CHI 2003, pp. 249-256.

[14] J. Kalbach, T. Bosenick, Web page layout: A comparison between left and right-justified site navigation menus, Journal of Digital Information, 4(1) (2003). Retrieved August 2008, from http://jodi.tamu.edu/Articles/v04/i01/Kalbach/.

[15] M. Khordad, M. Shamsfard & F. Kazemeyni, A hybrid method to categorize HTML document, In: Proc 6th Int. Conf. Data Mining, Text Mining and their Business Applications, 2005, pp. 331-340.

[16] J.R. Kingsburg, A.D. Andre, A comparison of three-level web menus: Navigation structures, In: Proc. The Human Factors and Ergonomics Society Annual Meeting (2004)

[17] S. Kumar, V. S. Jacob and C. Sriskandarajah, Scheduling advertisements on a web page to maximize revenue, European journal of operational research, 173 (2006) 1067-1089.

[18] L.J.P. van der Maaten, An Introduction to Dimensionality Reduction Using Matlab, Technical Report MICC-IKAT 07-06, Maastricht University, Maastricht, The Netherlands, 2007. Retrieved August 2008 from http://www.cs.unimaas.nl/l.vandermaaten/Laurens_van_der_Maaten/Publications_files/Demonstration1.pdf

[19] C. T. Meadow, Text information retrieval systems, Academic Press, San Diego, CA, 1992

[20] F. Menczer, G. Pant, P. Srinivasan, Topical web crawlers: Evaluating adaptive algorithm, ACM Transactions on Internet Technology (TOIT), 4 (4) (2004) 378-419.

[21] M. Niemela, J. Saarinen, Visual search for grouped versus ungrouped icons in a computer interface. *Human Factors*, 42(4) (2000) 630-635.

[22] V.L. O'Day, R. Jeffries, Information artisans: patterns of result sharing by information searchers, In: Proc. of the ACM Conf. on Organizational Computing Systems, COOCS, Milpitas, CA, 1993, pp. 98– 107.

[23] C.J. van Rijsbergen, S.E. Robertson and M.F. Porter, New models in probabilistic information retrieval, British Library (British Library Research and Development Report, no. 5587), London, 1980

[24] M. Sahami, S. Yusufali, M. Baldonado, SONIA: a service for organising networked information autonomously, In: Proc. 3rd ACM Conf. Digital libraries, Pittsburgh, Pennsylvania, United States, 1998, pp. 200-209.

[25] G. Salton, C. Buckley, Term-weighting approaches in automatic text retrieval, Information Processing & Management, 24 (5) (1998) 513–523.

[26] F. Sebastiani, Machine learning in automated text categorization, ACM Computing Surveys (CSUR), 34 (1) (2002) 1-47.

[27] N. Stojanovic, A. Maedche, S. Staab, R. Studer, Y. Sure, SEAL – A Framework for Developing SEmantic PortALs, In: Proc. 1st Int. Conf. Knowledge capture, 2001, pp. 155-162.

[28] T.Yan, M.Jacobsen, H. Garcia-Molina, U.Dayal, From user access patterns to dynamic hypertext linking, In: Proc. 5th Int. WWW Conf. Computer Networks and ISDN, 1996, pp. 1007-1014.

Ievgen S. Sakalo was born in Kharkiv, Ukraine, 1986.
Graduated from the Kharkiv National University of Radio Electronics (KhNURE) majoring in intelligent decision support system. In 2011 defended his thesis for a Ph.D. degree in KhNURE on the subject "Frame image processing based on artificial neural networks". He works (2008 - now) senior lecturer of KhNURE.

Mr Filatov was born in Kharkiv Ukraine, 1983.
Mr Filatov has graduated as MSc (computer science and management) from Kharkiv National University of Radio Electronics (1999-2005), Kharkiv, Ukraine, majoring in computer systems and networks. Mr Filatov has also graduated as MPhil (data mining and knowledge discovery) from University of Wales (2004-2005), Cardiff, United Kingdom, majoring in information systems, data mining & knowledge discovery. During 2005-2007 on site and remotely afterwards Mr Filatov has worked as a PhD researcher at Wessex Insitute of Technology, Southampton, United Kingdom, majoring in intelligent analysis and self organising web interfaces.
He works (2007 – now) as a director of a software development company, Injoit Ltd, London, United Kingdom, which majors in smartphone software development, complex cloud systems and data visualization where he employs his computer science experience.

Viktor Popov graduated from Technical Physics Department at the Faculty of Electrical Engineering - Belgrade University. He obtained his PhD from the Wessex Institute of Techology/University of Wales in the area of Environmental Modelling in 1997. He works in the field of numerical modelling, predominantly CFD. He is Head of Environmental Fluid Mechanics at the Wessex Institute of Technology.

Warehouse Management System in Ruby on Rails Framework on Cloud Computing Architecture

Kamil Durski, Jan Murlewski, Dariusz Makowski, Bartosz Sakowicz

Abstract – **This article describes internet-based application for warehouse management written in Ruby with use of Ruby on Rails framework and distributed as Software as a Service (SaaS) platform. This approach allows for great compatibility between operating systems as well as makes it possible to access application from all kind of devices – from standalone desktop computers up to tables and all kind of mobile devices. Example application was developed in Ruby on Rails version 2.3.**

Keywords –**Warehouse Management, Ruby, Rails, SaaS**

I. INTRODUCTION

These days Internet is the faster developing medium in the whole World. It is not only available via landline, but also mobile phone networks and still growing Wi-Fi hotspots. Along with the global network accessibility, the amount of mobile devices grows. More and more popular are telephones with screens exceeding 3″ as well as netbooks – small laptops with screen size of 10″.

This development in mobile technologies makes present business solutions obsolete and outdated. Most of current Enterprise Resource Planning (ERP) software is published and licensed per seat – meaning they are tied to specific computers, usually stationed in offices. Another disadvantage is the need of installation the software itself as well as additional, required packages and libraries (like frameworks or relational databases).

From the end user point of view, using ERP software via Internet browser should make their work considerably easier and shorten the time required to complete tasks. Applications like Internet Explorer, Firefox or Safari are pre-installed on almost every device that can access Internet. The need of software installation is removed completely, which guarantees that user can access application from virtually everywhere: in business trip via mobile or netbook, in the office and, if needed, from home.

This kind of software is not tied to specific hardware or software platforms. For example, apart from creating orders by phone or in the e-commerce store, company agent can check product availability and place new order directly at client's office.

During past few years a lot of web frameworks [1] were created, most of them in PHP language – Zend Framework, Kohana, CakePHP to name a few. They are very useful at what they do, however they are all limited by language itself, which, like most of popular tools, is struggling with backward compatibility and therefore does not even support all of Object Oriented Programming paradigm. To overcome this, some people dedicated to create web frameworks in different programming languages. Out of those two become vastly popular – Django [2] in Python and Ruby on Rails [3] in Ruby.

Ruby in Rails (short: Rails) is a framework with three basic principles:

1. Convection over Configuration guarantees short (if at all) configuration needed by application.
2. Do not Repeat Yourself (DRY) ensures that no piece of code should be repeated more then once.
3. Model-View-Controller as a main architectural pattern that helps to separate data from logic and templates [20].

This approach allows reducing time needed to create application but has some disadvantages as well. Things like connections between database and class names are created automatically at the cost of reserved names for objects, methods and attributes. Lack of attention might cause conflicts and unpredictable behavior as a result.

Rails application works on top of a webserver. By default Webrick is used, however it is possible to use other solutions like Mongrel or even Apache using Passenger module [4]. The full data flow between end-user and application is shown on Figure 1.
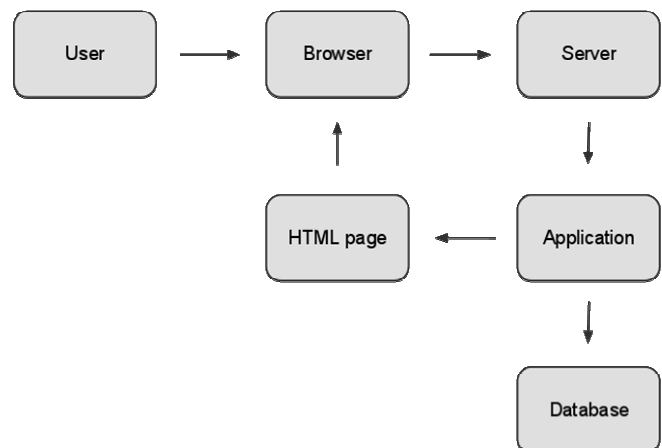

Fig. 1. Client – Server data flow

II. APPLICATION GOALS

Developed software allows for managing product, orders and clients. Because it is a web application, it will be possible to access it with all popular web browsers. When visiting page, user will need to sign in with three credentials – besides the usual username and password there will also be Account ID. This text-type field will be used to identify user's company within our platform.

As stated before, application will be distributes as SaaS [5]. In this model more than one client is handled by single application instance, and in order to identify client uniqueness we will need additional field. SaaS has a lot of advantages – it offers cost reduction for users and simplified software distribution for developers. Because all of the code is kept at one place, upgrading process is much faster and instantly applies to all of customers.

It is also possible to integrate developed software with third party applications using API. Two methods were created for that purpose – one for checking item's availability and one for adding new orders.

III. ARCHITECTURE

Described application was created using Model-View-Controller pattern used to separate data from logic and templates. Representational State Transfer (REST) [6] was used as well. This particular architecture was designed for stateless protocols (like HTTP) and defines sets of methods that should be used when creating web services.

TABLE 1
HTTP method used in web services

Method	Is safe?	Is idempotent?
GET	YES	YES
POST	NO	NO
PUT	NO	YES
DELETE	NO	YES

HTTP specification, as described in RFC 2616 [7], describes 8 methods, each one being at the same time English verb. Four of those methods are used for diagnostic and informational purposes and are not used by our application. The other four methods are used to create, read, update and delete resources and their short comparison can be seen in Table 1.

IV. ACTIVE RECORD

Ruby on Rails by default uses Active Record [8] design pattern. It is used in Object-relational_mapping (ORM) and allows to access database fields via class attributes and methods [21]. All information about database's tables and its fields is automatically gathered when object is initialized and adequate methods are created.

As an example we can use simple table called *products* with two columns – *name* (string) and *price* (decimal). In such a case Active Record class name should be *Product*. In order to create new record in database, which executing query below would typically do [23]:

```
INSERT INTO products (name, price) VALUES
('Item 1', 99.99);
```

we could just run the following Ruby code:

```
product = Product.new
product.name = "Item 1"
product.price = 99.99
product.save!
```
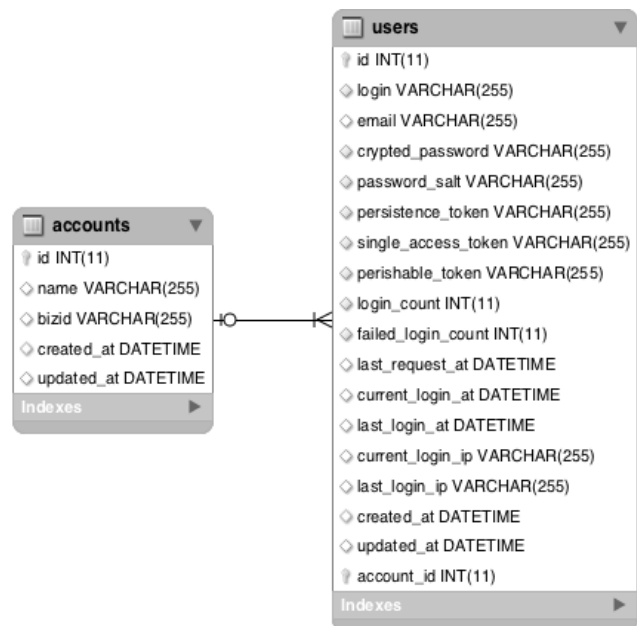

Fig. 2. *Users* and *accounts* table schema

In order to store data within application the MySQL 5.1 database is used [9, 10, 19]. It is free software with open source code, fully compatible with ANSI SQL standards. It supports relations and transactions (if InnoDB engine is used) and supports virtually all modern operating systems.

To configure MySQL a special file needs to be created under *config* directory of our application called *database.yml*. That file will keep authentication details. Example is shown on Figure 3.

```
development:
host: localhost
adapter: mysql
encoding: utf8
database: example_db
username: root
password: ****
```

Fig. 3. Example database.yml file

On Figure 2 a schema of two main tables is shown – *users* and *accounts*. Fields *users.account_id* is connected to *accounts.id* with foreign key and severs as a base for SaaS model.

V. FRONT END

Front end of our application was created in HTML 5 [11] - fairly new standard, which is slowly replacing its predecessors (HTML 4.01 and XHTML 1.1) [18]. It is still under development, however current browsers already support most of its features. HTML 5 is much more elastic and implements a lot of new tags and attributes but most important – makes browser independent from third party plugins used to play audio or video (required codecs are now built-in).

In order to simplify HTML creation process a different markup language was used – Haml [12]. It is an abstract description of (X)HTML along with some helpers that allow to create dynamic content. Haml greatly simplifies the process of HTML writing and the created code is even up to 50% smaller, as shown on Figure 4 and Figure 5.

```
#box
  .title
    %h1
      = link_to @title, page_url
  .content
      %p= render :partial => 'box_content'
```

Fig. 4. Example Haml code

```
<div id="box">
  <div class="title">
    <h1><%= link_to @title, page_url
%></h1>
  </div>
  <div class="content">
    <p><%= render :partial =>
'box_content' %></p>
  </div>
</div>
```

Fig. 5 Example HTML code

It is very easy to notice that Haml code takes less space and uses very few special characters.

Along with HTML we will also use Cascading Style Sheet (CSS) to separate page content from presentation details. On top of it we will use jQuery - JavaScript library that will allow to add some dynamic effects to website, like dropdown menus and simple AJAX features [22].

VI. BACK END

One of the biggest features of Rails is support for external plugins. Their main role is to extend functionality with sets of features that did not make it into the core of framework.

And so our application uses a few of them listed below:
–   **MySQL** – database support.

–   **Haml** – enables support for markup language with the same name.
–   **Authlogic** – small and easy extension that allows to quickly implement web session and users authentication. Also supports Facebook, Twitter and OpenID integration.
–   **Searchlogic** – extensively use metaprogramming feature in Ruby by creating set of methods for Rails model that allows finding records in database with easy.
–   **JRails** – drops Prototype JavaScript library support in favor of jQuery [12,13].
–   **Formtastic** – creates helper methods for HTML forms and automatically generates necessary fields that are semantically valid. Also supports model relationships and implements advanced internationalization methods.
–   **Inherited Resource** – easy REST support for Rails application. This plugin extend Rails with module that automatically adds methods to controller class that create, read, update and delete resources – no additional code is required.
–   **Responders** – small extension that add necessary headers to sessions and HTTP headers when adding, updating or deleting database records. Required by Inherited Resources.

In order to better understand the full capability of rails plugins in the Figure 6 a simple controller class is shown.

```
class CustomersController <
InheritedResources::Base
      before_filter :check_account, :only =>
[:show, :edit, :update, :destroy]
      before_filter :require_user
      respond_to :js, :only => [:index]
end
```

Fig. 6 Source code of customer's controller

This small piece of code is responsible for all operations run on customer records – create, read, update and delete – no coding is needed thanks to its parent class from Inherited Resources plugin. Besides that it also call methods used to validate user and its access before running record-based methods and makes sure that index action will respond to JavaScript requests (used in AJAX - based record filters).

VII. SUMMARY

The main purpose of created application was to show that Ruby on Rails is a real competition for currently most popular PHP language and its frameworks. Even though less then 5% of sites use Ruby it is stable and supported enough to be capable of running big commercial projects thanks to one of its main advantages - speed. Even though in benchmarks the efficiently of different Ruby implementations is substantial [15], its still a lot faster then PHP. A few of most popular Ruby project include Twitter or Dig social networks or widely used business solutions offered by 37 Signals – Basecamp and Campfire.

Although Ruby and Rails are available for Microsoft Windows it is still best supported in Unix operating systems

like Linux or MacOS X thanks to command-line utility called "gem". Created application was developed with Firefox, Safari and Internet Explorer in mind and works seamlessly under desktop computers as well as mobile systems like iOS and Android.

Example integration can be easily created using built-in API support in designed application. E-commerce stores or any other application that allows for XML integration can be synchronized. This approach did not create much of additional work. In fact it was a matter of adding a few new template files and some additional logic to controllers. Everything else was handled directly by Rails framework core components.

Ruby language might be hard for people that are used to imperative programming languages (like C/C++ or Java), as its core language constructions are a bit different and so is approach to some problems. Nonetheless after reading some popular books and tutorials [16,17] most of the people will appreciate what it has to offer and how much easier and faster programming can be.

REFERENCES

[1] PHP Frameworks, http://www.phpframeworks.com/
[2] Django project, http://www.djangoproject.com/
[3] Ruby on Rails, http://rubyonrails.org/
[4] Phusion Passenger, http://www.modrails.com/
[5] NIST – Computer Security Division – Cloud Computing, http://csrc.nist.gov/groups/SNS/cloud-computing/
[6] Roy Fieldings Dissertation, Chapter 5, http://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm
[7] RFC 2616 – HTTP/1.1, http://tools.ietf.org/html/rfc2616
[8] ActiveRecord,http://api.rubyonrails.org/classes/ActiveRecord/Base.html
[9] MySQL 5 Storage Engines http://dev.mysql.com/doc/refman/5.0/en/storage-engines.html
[10] MySQL 5.1 Numeric Types http://dev.mysql.com/doc/refman/5.1/en/numeric-type-overview.html
[11] W3C HTML5 Specification, http://www.w3.org/TR/html5/
[12] HAML Reference, http://haml-lang.com/docs/yardoc/file.HAML_REFERENCE.html
[13] Prototype JavaScript framework, http://www.prototypejs.org/
[14] jQuery, http://www.jquery.com/
[15] The Great Ruby Shootout (July 2010), http://programmingzen.com/2010/07/19/the-great-ruby-shootout-july-2010/
[16] Sam Ruby, Dave Thomas, David Heinemeier Hannson, *Agile Web Development With Rails 3rd Edition*, The Pragmatic Bookshelf, June 2008
[17] Ruby in Twenty Minutes, http://www.ruby-lang.org/en/documentation/quickstart/4/
[18] Sakowicz B., Wójtowski M., Zalewski P., Napieralski A., „ Problems of Standardization in Web Technologies" XI Konferencja „ Sieci i Systemy Informatyczne, Łódź, październik 2003, pp. 111-114, ISBN 83-88742-91-4
[19] Wilk S., Sakowicz B., Napieralski A.," Wdrażanie aplikacji J2EE w oparciu o serwer Tomcat 5.0 i bazę danych MySQL" SIS XII Konferencja, Łódź październik 2004, pp.379-386, ISBN 83-7415-042-4
[20] Wojciechowski J., Sakowicz B., Dura K., Napieralski A.," MVC model struts framework and file upload issues in web applications based on J2EE platform" TCSET'2004, 24-28 Feb. 2004, Lviv, Ukraine, pp., 342-345 , ISBN 966-553-380-0
[21] Ziemniak P., Sakowicz B., Napieralski A.: "Object oriented application cooperation methods with relational database (ORM) based on J2EE Technology"; CADSM'2007; ISBN 978-966-553-587-4
[22] Cisz, M.; Zabierowski, W.: "Community services portal based on the campus of Technical University of Lodz. Using Ajax technology".; TCSET 2010 , Page(s): 183 - 184; ISBN 978-966-553-875-2
[23] Murlewski J., Kowalski T., Adamus R., Sakowicz B., Napieralski A., "Query Optimization in Grid Databases", 14th International Conference Mixed Design of Integrated Circuits and Systems MIXDES 2007, 21-23, str. 707-710, ISBN 83-922632-4-3

Innovative Data Collecting System of Services Provided by Medical Laboratories

Adam Migodzinski, Robert Ritter, Marek Kaminski, Jakub Chlapinski, Bartosz Sakowicz

Abstract – **The article presents features of an innovative system that provides data collection of services provided by medical laboratories. System has been developed based on Java Enterprise Edition platform with usage of Spring and Hibernate frameworks combined with jQuery library.**

Keywords – **Spring Framework, Hibernate, Java, Java EE**

I. INTRODUCTION

RECENTLY Internet has become the main source of information, entertainment, knowledge and platform for the rapid exchange of information. However, this is just one of the possibilities of using this powerful tool. In the last few years, strong growth of Internet's commercial use has marked. More and more companies began to share their databases of products and prices with the possibility to purchase them via Internet. A growing number of online shops caused creation of price comparison services - websites thanks to which users can quickly find an interesting product in the lowest price.

Presented application is innovative because there has not been introduced any website offering such set of services. Its introduction in future may be significantly easier for physicians and patients.

The aim of the work was to create a site collecting data on services provided by medical laboratories, with usage of open-source solutions (jQuery, Hibernate, MySQL, Tomcat) and technology based on Java EE and Spring framework [1,2].

II. TOOLS USED TO DEVELOP THE SYSTEM

Main idea of the project was to create a site, making use only of open-source libraries and projects. Authors decided to use Java and the Spring Framework as the foundation of the whole project, together with other supplementary technologies such as Hibernate or jQuery. Apache Tomcat has been chosen as application's server. System security has been assured through the use of Spring Security framework. Good knowledge of mentioned frameworks allows to accelerate the application development process. Unfortunately, their use does not guarantee success itself. Much depends on the programmer, who must remember to apply certain rules such

as three-layer application architecture. Thanks to the program code becomes transparent and the development of applications in the future – easier.

III. SYSTEM GOALS AND FUNCTIONALITY

The main aim of the project was to design system that would be a database of laboratories together with their offered medical examinations. Furthermore, it should provide quick searching of any examination with the possibility of price comparison. Such a system would constitute a huge convenience to both doctors and their patients searching for the best place to do the required tests [6].

System is addressed to various range of users. Due to this fact, division into four main roles of users was implemented. The roles are: laboratory worker, administrator, client and registered client. Each role has different functionality.

Laboratory worker role functionality:
- registration in the system
- adding examinations
- submitting newsletter content
- adding comments and files

Registered client can:
- search for examinations
- add opinion about laboratory
- register for newsletter

Client:
- search for examinations

Administrator functions are:
- moderating laboratory's opinions
- editing and sending newsletter
- placing commercial banners

IV. ARCHITECTURE

Application has been designed in accordance with three-tier layer architecture (Fig. 1).
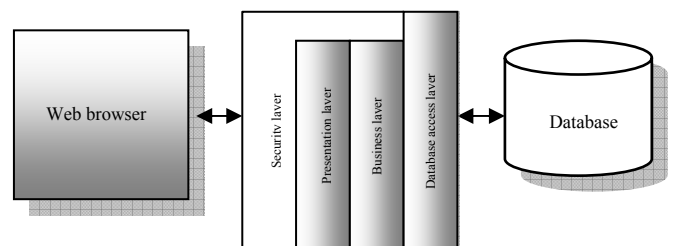

Fig. 1. Application's architecture

It distinguishes three independent modules. These modules are associated with each other by means of appropriate mechanisms to ensure communication between them and the

data transfer. The three modules are: presentation layer, business layer and database access layer. The correct model layer should be constructed so that the given layer uses the interface provided by the "lower" layer to communicate and have no knowledge of any "higher" layer. Such architecture is demanded by Spring Framework, which requires object-oriented programming with interfaces, loose-coupling between classes and modularity.

V. BUSINESS LOGIC LAYER

Business logic layer in the application has specific tasks. It collects data from a "lower" layer through its interfaces. Persistence layer forwards data to the logic layer as objects.
It is run by:

service-Java interfaces providing class' methods for implementing the service,

Java classes that define methods for implementing business logic depending on user requests. Responsible for the retrieval of data from layers responsible for the access to the database, saving new objects mapped to the appropriate records in the database, editing existing ones or deleting them.

VI. PERSISTENCE LAYER

Persistence layer is the lowest layer in the application [3,7]. It is responsible for retrieving data from a database using annotated POJO classes pursuing an object-relational mapping. It is implemented with:

– DAO interfaces – which share methods of classes to implement the DAO interface;

– Java classes that inherit from class HibernateDAOSupport, giving access to a wide range of methods for ease of use of data, such as adding to the database or erasing them, without worrying about releasing the session objects, transactions, or cleaning the cache memory. They operate on the class's entities;

– entities – POJO class with JPA annotations implements the object-relational mapping to the appropriate tables in the database.

This design does not require changes in source code after changing data persistence technology.

All data is stored in a MySQL 5.1 database. However, implementation of applications that run on a relational database in object-oriented programming languages such as Java can be time consuming and tedious. Facilitate and accelerate the action has been obtained by the usage of Hibernate, that is performing the mapping application skeleton representation of the object model of the relational model, using SQL. Hibernate's configuration is stored in XML file. There is defined connection through JDBC to the database and SQL dialect, so that system specific metadata can be generated. Example of Hibernate configuration is shown below:

```
<hibernate-configuration>
  <session-factory>
    <property name="hibernate.dialect">
      org.hibernate.dialect.MySQLInnoDBDialect
    </property>
```

```
    <property
name="hibernate.connection.driver_class">
      com.mysql.jdbc.Driver
    </property>
    <property name="hibernate.connection.url">
      jdbc:mysql://localhost:3306/mediclabsdb
    </property>
    <property
name="hibernate.connection.username">root</pro
perty>
  </session-factory>
</hibernate-configuration>
```

In the project entities with annotations were used. Annotations in Hibernate are implemented in the Hibernate Core in the form of two independent packages: Hibernate Annotations and Hibernate EntityManager. Hibernate Annotations implements all annotations JPA / EJB 3.0. Java classes with annotations are replacing traditional XML mapping files. Below is presented Java class with annotations usage.

```
@Entity
@Table(name="authorities"
    ,catalog="mediclabsdb"
    , uniqueConstraints =
@UniqueConstraint(columnNames={"username",
"authority"})
)
public class Authorities  implements
java.io.Serializable {
    private Integer id;
    private Users users;

    public Authorities() {}
    public Authorities(Users users, String
authority) {
      this.users = users;
      this.authority = authority;
    }
    @Id @GeneratedValue(strategy=IDENTITY)
    @Column(name="id", unique=true,
nullable=false)
    public Integer getId() {
      return this.id;
    }
    public void setId(Integer id) {
      this.id = id;
    }
    @ManyToOne(fetch=FetchType.LAZY)
    @JoinColumn(name="username",
nullable=false)
    public Users getUsers() {
      return this.users;
    }
    public void setUsers(Users users) {
      this.users = users;
    }
```

VII. PRESENTATION LAYER

Presentation layer is located at the top of three-tier architecture. It is responsible for implementing user's interface logic and contains the code navigating between web pages or displaying the forms. In presented application

presentation layer has been implemented in accordance with the MVC (model-view-controller) pattern, which includes:

– JSP pages – which are views responsible for presenting data to the user. Data is imported through the middle tier from database. Pages are operated by controllers;

– Controllers – Java classes that inherit from one of Controller class, depending on the kind of ongoing user request. Controllers communicate with the "lower" layer using the interfaces provided by it, import the required information and return the results to the appropriate view. One controller can support several views (Fig. 2).
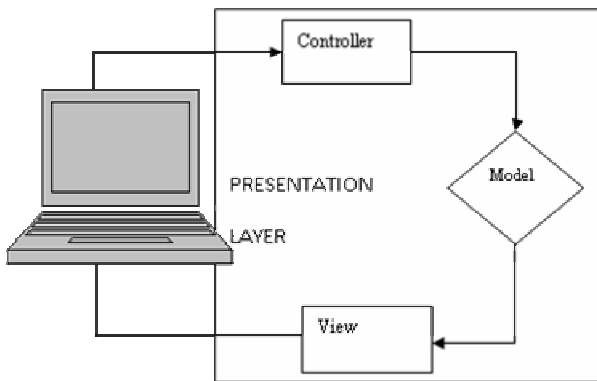

Fig. 2. Processing user's request step-by-step

Of course incoming request needs to be dispatched in some way. In other words it has to be known which controller is responsible of delivering essential data to JSP page. Spring provides several mapping methods but in presented project SimpleUrlHandleMapping was used. It maps controllers to URL adresses   using a property collection defined in the Spring application context, as presented below:

```
<bean id="urlMapping"
class="org.springframework.web.servlet.handler
.SimpleUrlHandlerMapping">
  <property name="mappings">
    <props>
      <prop key="index*.htm">
            indexController
      </prop>
      <prop key="image/*.htm">
            imageController
       </prop>
     </props>
    </property>

</bean>
```

User interface has been enriched by jQuery plugins such as: tablesorter, masked input, autocomplete input field or ligthbox gallery [4]. jQuery is a cross-browser JavaScript library designed to simplify client-side HTML scripting. Implementing any plugin from those mentioned above is very easy. Basically it boils down to import appropriate plugin's script and putting path to it in <head> section. Next step is putting in separate JavaScript file methods that the plugin

implements or extends and a single line "$(document).ready() executing specific actions. Sample usage of Autocomplete plugin is presented on Fig. 3 and the code is introduced below:

```
$(document).ready(function(){
$("input#cities").autocomplete({
source:[ "Zgierz", "Zgorzelec"]
    });
  });
```
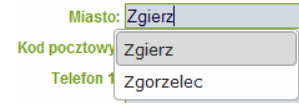

Fig. 3. jQuery UI autocomplete plugin in action

VIII. SECURITY LAYER

Ensuring application security is a critical aspect of its proper work [5,8,9]. When one needs to divide access to resources depending on user role, the help comes from the Spring Security framework. To work properly, "Spring Security" needs two tables to be created in the database: USERS and AUTHORITIES. First of these two must be fields storing two fields: username and password. In the second table must be username (which is a foreign key) and the name of the his role (authority). Spring Security configuration has been defined in a separate file - applicationContext-security.xml. It identifies the access to websites based on user role, the name of the page responsible for logging in, redirects to the appropriate page when one logs on, logs off or if the login fails:

```
<http auto-config="true" lowercase-
comparisons="false" access-denied-
page="/index.jsp">
<intercept-url pattern="/login.jsp"
access="IS_AUTHENTICATED_ANONYMOUSLY" />
<intercept-url pattern="/index*.jsp"
access="IS_AUTHENTICATED_ANONYMOUSLY"/>
      ...
<intercept-url pattern="/profile.jsp"
access="ROLE_USER, ROLE_ADMIN" />
<form-login login-page="/login.jsp"
authentication-failure
url="/login.jsp?login_error=1" />
<logout logout-url="/logout" logout-success-
url="/index.jsp" />
</http>
```

To enable the security methods for applications, filers capturing users requests need to be configured in the application descriptor (web.xml file), as shown below:
```
<filter>
      <filter-name>springSecurityFilterChain
      </filter-name>
      <filter-class>
org.springframework.web.filter.DelegatingFilte
rProxy
      </filter-class>
</filter>
    <filter-mapping>
      <filter-name>springSecurityFilterChain
```

```
        </filter-name>
        <url-pattern>/*</url-pattern>
</filter-mapping>
```

IX. USAGE OF JMS AND CKEDITOR

The system introduces the ability to send newsletters to users who have expressed their desire to receive it. Spring Framework has an abstract API that makes sending e-mails a relatively simple process. A main element of that API is an interface MailSender, which has two different implementations. In the project JavaMailSenderImpl was used. The reason why this one has been chosen is its possibility of sending the MIME messages. Responsible for sending emails is method sendEmail, located in the class EmailServiceImpl class. This method creates and send messages to each customer. For the proper work of the mechanism, relevant beans must have been defined in the applicationContext.xml file:

```
<bean id="mailsender"
class="org.springframework.mail.javamail.JavaM
ailSenderImpl">
      <property name="host">
<value>${host}</value></property>
      <property name="port">
<value>${port}</value></property>
      <property name="username">
<value>${username}</value></property>
      <property name="password">
<value>${password}</value></property>
      <property name="javaMailProperties">
       <props>
       <prop key="mail.smtp.auth">true</prop>
       <prop
key="mail.smtp.starttls.enable">true</prop>
            </props>
      </property>
</bean>
```

PropertyPlaceholderConfigurer loads properties from one or more external property files and uses those properties to fill in placeholder variables in the bean wiring XML file.

```
<bean id="propertyPlaceholder"
class="org.springframework.beans.factory.confi
g.PropertyPlaceholderConfigurer">
<property name="location"
value="mailsystem.properties"></property>
</bean>
```
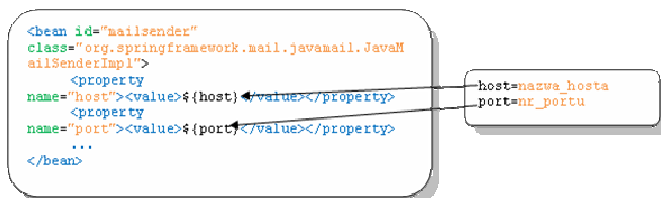

Fig. 4. Properties import from external property file

X. CONCLUSIONS

In recent years much has changed in approach of creating applications that run on the web server. Role of frameworks, which support creation of application, its development and testing has increased. Examples are the Spring Framework (for Java), Code Igniter (PHP). NET Framework and many others. The aim of this study was to establish a system for collecting information of medical laboratories and their services. It would greatly facilitate the work of doctors and saved patient's time who is searching for relevant laboratory to do the examination. Such a system could improve the quality of services due to the possibility of comparing prices or adding an opinion of the laboratory.

REFERENCES

[1] Craig Walls, Ryan Breidenbach, „Spring in Action – Second Edition", Manning Publications, 2007, ISBN: 1-9339-8813-4.
[2] R. Johnson, J. Hoeller, A. Arendsen, T. Risberg, C. Sampaleanu, „Professional Java Development with the Spring Framework, John Wiley & Sons, 2005, ISBN: 0-7645-7483-3.
[3] Christian Bauer, Gavin King, "Hibernate w akcji", Helion, 2007, ISBN: 978-83-246-0527-9.
[4] Bear Bibeault, Yehuda Katz, "jQuery in Action", Manning Publications, 2008, ISBN: 1-9339-8835-5.
[5] John Arthur, Shiva Azadegan, "Spring Framework for Rapid Open Source J2EE Web Application Development: A Case Study," snpd-sawn, pp.90-95, Sixth International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing and First ACIS International Workshop on Self-Assembling Wireless Networks (SNPD/SAWN'05), 2005.
[6] Niziałek, A.; Zabierowski, W.; Napieralski, A.: "Application of JEE 5 technologies for a system to support dental clinic management"; Modern Problems of Radio Engineering, Telecommunications and Computer Science, 2008 , ISBN978-966-553-678-9
[7] Ziemniak Piotr, Sakowicz Bartosz, Napieralski Andrzej: "Object oriented application cooperation methods with relational database (ORM) based on J2EE Technology"; CADSM'2007; 9th International Conference The Experience Of Designing And Application Of Cad Systems In Microelectronics, Polyana, Ukraina, 20 - 24 February 2007, str. 327-330, s.593, A4, ISBN 978-966-553-587-4, wyd. Publishing House of Lviv Polytechnic National University 2007.
[8] PilichowskiI M., Sakowicz B., Chłapiński J.; "Real-time Auction Service Application Based on Frameworks Available for J2EE Platform", pp. 166-169, Proceedings of the Xth International Conference TCSET'2010, "Modern Problems of Radio Engineering, Telecommunications and Computer Science", Lviv-Slavsko, Ukraina, 23-27 February 2010, s.380, A4, wyd. Publishing House of Lviv Polytechnic National University 2010, ISBN 978-966-553-875-2
[9] Marcin Mela, Bartosz Sakowicz, Jakub Chlapinski: "Advertising Service Based on Spring Framework", 9th International Conference Modern Problems of Radio Engineering, Telecommunications and Computer Science, TCSET'2008, 19-23 February 2008, Lviv-Slavsko, Ukraine, ISBN 978-966-553-678-9

The Use of Adobe Flex in Combination with Java EE Technology on the Example of Ticket Booking System

Przemysław Juszkiewicz, Bartosz Sakowicz, Piotr Mazur, Andrzej Napieralski

Abstract – **The article presents the possibility of building Rich Internet Applications using Flex technology as well as a method of connecting them with Java EE applications based on a Spring framework. As an example, a ticket booking system was created. The most important issues related to rich internet applications and possibilities of used technologies were shown basing on this system. The application was elaborated owning to usage of the latest open-source technologies.**

Keywords – **Rich Internet Application, Flex, BlazeDS, PureMVC**

I. INTRODUCTION

THE dynamic growth of the Internet over the past several years has contributed to build of a new type of applications - page-based applications [4]. In applications of this type all the data and operations are carried out in one place, which significantly decreases the cost of updating and modernization [8].

However, this solution proved to be not quite perfect, and the reason for this restriction was simple and limited user interface based on HTML technology. Despite the development of HTML language and the use of Dynamic HTML elements (DHTML), the solution was still not sufficient. The incompatibility of this type of application in different browsers forced the developers to create multiple versions of applications for different browsers running on different operating systems.

The solution to the problems of building a business applications has become **Rich Internet Applications** (RIA applications) [9].

One of the main aim of RIAs are moving away from page-based applications, reducing amount of data needed to

be transferred, provide a simple application status service, providing an interface known from the normal desktop applications and the ability to operate without connecting to the network:

– departure from page-based applications causes that the page is not generated each time the user performs an operation , and it has directly affects on the amount of data transferred from server to client, pmaz, napier} @dmcs.pl.

– Rich Internet Applications use the resources of user computer, this situation makes that the application state may be stored in RAM, unlike the use of stateless HTTP protocol.

Rich Internet Applications are attractive to users and to Internet Service Providers (ISPs). These applications reduce server load, network traffic and data load time. It does not restrict developers when they create the application interface and provide the same feel and look in different environments [7].

II. TECHNOLOGIES AND TOOLS USED TO DEVELOP THE SYSTEM

To build the system authors used the open-source technologies and tools. The basic technology for building the client application is Adobe Flex and PureMVC (most known MVC Flex application framework). Server side application was built using Java and the Spring application framework. This makes the system more flexible and easy to expand. Communication between client and server application is based on Spring BlazeDS Integration project (SBI) and BlazeDS server.

III. DESCRIPTION OF THE CREATED SYSTEM

Ticket booking system is based on two technologies, Java EE and Adobe Flex. Both technologies are constantly and dynamically developed, and Java EE is currently one of the most commonly used technology for building business applications [3].

The system was built as desktop application. The user who wants to install and run it needs the **Adobe AIR** platform. It is also possible to build system as a web application which uses web browser and **Adobe Flash Player** plugin to run.

The main aim of system is to allow reservation of elements (called main elements in the system). The system is designed for booking abstract elements that can be represented, for example, by the film, concert, artistic events, etc.. Each element consists of a description, name, registration type which is necessary for booking element (the system operator depending on the type of registration has to create new client account, or just enter the required informations). In addition, each element has a list of available sites for booking and date with the hours in which it is available. These data are needed to complete the booking process, a combination of dates, places, and an element defines a single reservation.

The system enables full management of the elements, users of the system (divided on the operators and administrators), customers and bookings. Additionally, the system allows to view system statistics, conduct the correspondence between the users of the system and print single bookings.

The system consists of two cooperating parts:
− server side is part of an Java EE application running on application server and it is build using **Spring** framework [10-12],
− client side is built in **Adobe Flex** technology in conjunction with the lightweight **PureMVC** framework that provides a simple application structure based on three elements: model, view and controller.

The cooperation of both server and client side is possible thanks to BlazeDS Spring Integration project. The project uses the BlazeDS server and gives it characteristics of Spring framework. This allows an application built in Flex to use the benefits provided by Spring framework and advantages of its use.

The client application uses two types of services provided by BlazeDS to communicate with the server: RemotingService (RPC - Remote Procedure Call) and MessagingService. RemotingService provides remote procedure call, and MessagingService provides the possibility of sending messages across multiple clients connected to the server.
− Remote Procedure Call is a service that is used to carry out all operations on data including add, delete, edit, and booking of the main elements, management of reservations, users and customers of the system, login to the system and loading a data for statistics.
− MessagingService is a service that is used to inform client applications about changes in the system. Changes cause a series of events and the initiation of operations aimed at synchronizing the state of the client application with the data on server. An example of such behaviour is to automatically log off the user whose account has been blocked by system administrator. At the time of the lock server sends to all client applications message about user who was blocked. The application, in which the blocked

user is currently logged on, automatically logout and return to the login screen.

PostgreSQL database was used by authors for storing data and give them the relation character. Thanks to usage of Spring framework and Hibernate persistence API data has the relational structure and it can be mapped to the object model and then send to the client application in that form.

Application architecture is shown in Fig. 1.

```
@Entity
@Table(name="users_details", schema="public")
public class UsersDetails implements Serializable {
        @Column(name="id", nullable=false)
        @Id
        private int id;

        @Column(name="name", nullable=true, length=255)
        private String name;
```

Fig. 1. Parts of POJO class with mappings

The set of used technologies provides the ability to easily expand the system with additional elements. The same services, data access layer, and the same set of security can be used, for example, to build a website for mobile devices, enabling users register and purchase tickets online.

IV. DATA LAYER

The relational database PostgreSQL 8.4 has been used to build an application. The project database was created using pgAdmin III, which is part of the database installation package. The system consists of nine tables connected with primary and foreign keys.

Thanks to using object-relational mapping (ORM) business logic can be implemented based on the objects representation, this approach solves the problem of incompatibility of models (called impedance mismatch) [1]. The use of ORM increases the readability of code and minimizes the time devoted to writing long and complicated SQL queries. Java class are mapped to relational database tables based on the annotation describing the mapping of objects in the tables. The part of the mapped java class is shown in Fig. 2.

```
package domain
{
[Bindable]
        [RemoteClass(alias="ticketbooking.domain.Reservat
ion")]
public class Reservation
{
        public var id:Number;
        public var date:Date;
        public var position:MainElementPosition;
        public var calendar:MainElementCalendar;
public var description:String;
        public var username:Users;
        }
}
```

Fig. 2. Definition and mapping of the Reservation class in client application

Implementation of the domain model is a very important element of the system. It is used in many places during implementation of the functionality of the system. It is important that the implementation of this model was not related to other programming interfaces, and it has no influence on other tasks except for the business aspects [2].

Plain Old Java Objects (POJO) class are being used to implement the domain model of the system . Most POJO classes are working properly with Hibernate. It cause that Hibernate persistence API works the the most properly with business model implemented as POJO [2].

Domain model which is used in the server application is closely mapped to the model used in the client application written in Adobe Flex technology. BlazeDS application server and Flex allow for serialization of data between ActionScript language and Java. Implementation of the model in ActionScript and mapping it to Java class requires an addition of the RemoteClass tag to the class definition, specifying the package and the Java class, which the ActionScript class corresponds to. Example showing the definition and mapping of the Reservation class is shown in Fig. 3.
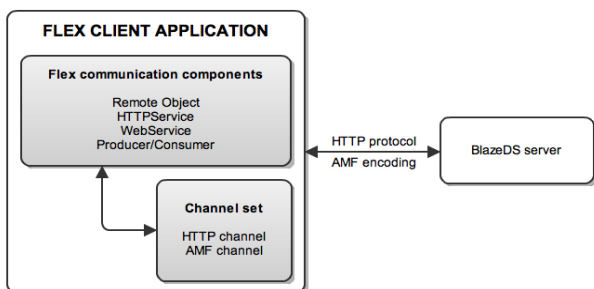

Fig. 3. Architecture of the client application using BlazeDS server

V. MVC ARCHITECTURE

MVC architecture (Table 1) was used in both parts of the application, the server part and client part. MVC architecture has the most important significance in the case of the client application, because there is a whole process of interaction between the user and application interface. The use of PureMVC framework provides a uniform method of controlling an application based on events (called event-driven) at every level.

Application data model consists of nine proxy objects. Almost every object from the domain model corresponds to the correct proxy object, in addition SecurityProxy object is responsible for maintaining security of the system. The main element of each proxy object are proxy responsible for cooperating with the part of the server [5]. These methods are only wrapper methods to cooperate with a specific remote service by using RemoteObject components.

Framework term view in Pure MVC is directly related to the mediator object. The system consists of several mediators, each responsible for a particular component of the user interface. All mediators shall cooperate among themselves and with other components using the PureMVC notifications sent through sendNotification method [5].

Command objects are corresponding to controllers which are the part of the PureMVC framework. In the described system command objects have two roles.
The first is the initial configuration of the framework, which includes registration of all mediators and proxy objects. The second one is the response to the notifications sent by the mediator-type objects and performing operations on proxy objects.

TABLE 1
MVC layer characteristics

Layer	Description
Model	Represents data, their logic and relations.
View	Responsible for displaying the data represented by the model.
Controller	Responsible for actions performed by the user and update the data represented by the model.

VI. COMMUNICATION LAYER

BlazeDS server provides highly scalable access to remote procedure calls service (RPC) and messaging services for client applications built in Adobe Flex technology. In other words, BlazeDS enables client applications to access data stored on a remote server and the exchange of messages between multiple clients connected to the server.

Communication layer consists of three types of Flex components: RemoteObject, Consumer and ChannelSet. Each of the RemoteObject components is connected to a server-side service. Consumer component and ChannelSet component are responsible for receiving messages sent from server to client application. Communication between the client application and BlazeDS server is shown in Fig. 4.

All communication between the Flex application and the BlazeDS server is based on the messages. Flex components use few types of messages to communicate with the corresponding server-side services. BlazeDS server uses two patterns of message:

- Request/reply pattern is used by RemoteObject, HTTPService, WebService Flex components. A component sends a request to a server and receives an answer.
- Published/subscribe pattern is used by the Producer and Consumer Flex components. Producer publish messages, and then the Consumer receives messages published by other customers.

Server-side application is a web application which runs on the Java EE application server. Requests from the client goes through the channel to the appropriate endpoint on the server. From the endpoint request goes through a series of Java objects such as MessageBroker, Service, Destination and Adapter [6]. When the request reach the last element it is supported by the appropriate java service.

VII. SECURITY LAYER

Security layer of the system was build thanks to the Spring Security package. This package is based on aspect-oriented programming. It cause that service layer of system can be design without thinking about security issue [1]. Application security is implemented at two levels.

− Securing a client application through the preparation of the application interface based on the roles of the user. Depending on roles of currently logged user, the various interface elements are shown and others are not shown.

− Securing access to services layer on the server-side application. This security is achieved thanks to annotations which are used in services declaration. The annotations describe which roles user has to poses to use specific service.

In addition, thanks to use of MessagingService and long polling technique available in BlazeDS server, application is equipped with an automatic logout process of the user whose account has been disabled by the administrator.

VIII. CONCLUSIONS

The main aim of this study was to show possibility of creating Rich Internet Applications based on Flex technology and how to combine them with the Java EE applications based on Spring framework. The process of creating an application was made in accordance with good practices aimed at reaching the goal of high quality computer system. Process consisted of the following stages: preparation of use cases, domain model and database, design of user interface, flow control and in the last stage implementation and testing of the system. In the result ticket booking system was created.

The resulting system is a multi-platform and can be constructed and implemented in two ways: as a desktop application which can be run using the Adobe AIR platform, or as a web application which can be run via a web browser. In addition, proposed solution caused that the system is very flexible and easily suitable for further development. The system is based on open-source technologies and it shows that it is possible to build a system which satisfies all the conditions of nowadays customers, without having to purchase expensive commercial licenses.

REFERENCES

[1] Rod Johnson, Juergen Hoeller, Alef Arendsen, Thomas Risberg, Colin Sampaleanu, *Spring Framework Profesjonalne Tworzenie Oprogramowania*, Helion, 2005

[2] Christian Bauer, Gavin King, *Hibernate w akcji*, Helion, 2007

[3] Deepak Alur, John Crupi, Dan Malks, *Core J2EE Wzorce projektowe*, Wydanie Drugie, Helion, 2004

[4] Jeff Tapper, Michael Labriola, Matthew Boles, James Talbot, *Adobe Flex 3 oficjalny podręcznik*, Helion, 2008

[5] Cliff Hall, *PureMVC Implementation Idioms and Best Practices*, http://www.puremvc.org, 03.02.2008

[6] *BlazeDS Developer Guide*, Adobe Systems Incorporated, http://livedocs.adobe.com, 2008

[7] Piero Fraternali, Gustavo Rossi, Fernando Sánchez-Figueroa, *Rich Internet Applications*, IEEE Internet Computing, vol. 14, no. 3, pp. 9-12, May/June 2010, doi:10.1109/MIC.2010.76

[8] J. Farrell, G.S. Nezlek, *Rich Internet Applications The Next Stage of Application Development*, Information Technology Interfaces, 2007. ITI 2007. 29th International Conference on. 25/07/2007

[9] Dębiński A., Sakowicz B., Kamiński M.: "Methods of Creating Graphical Interfaces of Web Applications based on the Example of FLEX Framework", pp. 170-173; TCSET'2010, ISBN 978-966-553-875-2

[10] Janas, R.; Zabierowski, W.; "Brief overview of JEE"; Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET), 2010 International Conference on; 2010 , Page(s): 174 - 176, ISBN 978-966-553-875-2

[11] Ritter R., Sakowicz B.: "Publishing and decisioning bidding system based on J2EE platform in combination with spring and hibernate technology", CADSM 2009, Ukraina, ISBN 978-966-2191-05-9

[12] Sakowicz B., Wojciechowski J., Dura. K. „Metody budowania wielowarstwowych aplikacji lokalnych i rozproszonych w oparciu o technologię Java 2 Enterprise Editon" Mikroelektronika i Informatyka, maj 2004, KTMiI P.Ł. , pp. 163-168, ISBN 83-919289-5-0

BB84 Analysis of Operation and Practical Considerations and Implementations of Quantum Key Distribution Systems

Patryk Winiarczyk, Wojciech Zabierowski

Abstract — **Nowadays cryptography is applied in more and more applications. Most often asymmetric or hybrid systems are used, which are based on mathematical concepts. However, a promising family of quantum solutions tries to take over control. This article describes a technique of quantum key distribution called BB84. It gives an insight into quantum physics governing the proper operation of any system in quantum cryptography and then presents the detailed analysis of BB48 system. Its operation and security it provides are discussed. Next aspect that is covered is dedicated to practical considerations of quantum cryptography. All basic problems encountered while implementing BB84 or any other quantum system are explained.**

Index Terms—**QKD, quantum cryptography, quantum physics, photon, BB84**

I. INTRODUCTION

ANY quantum system in cryptography is based on Heisenberg's uncertainty principle, which causes its disturbance when it is measured and hence any form of eavesdropping can be quickly detected. This particular feature makes quantum cryptography superior to conventional cryptography. In literature, it can be often encountered that the name quantum key distribution, abbreviated as QKD is used instead of quantum cryptography. QKD is a more accurate name as such a quantum system is used for key distribution and not for data encryption itself. The first quantum key distribution technique was presented by Bennett and Brassard in 1984 and was named BB84 protocol. Its first experimental demonstration was performed in 1991. The protocol takes use of photon polarization states. In such a system quantum communication channel can be free space or an optical fibre and it can be open to public so that any form of an external interference is accepted. The data sent in the channel is encoded by means of non-orthogonal states. These states cannot be measured without disturbing the original state and such quantum characteristic ensures the security of the whole system. This characteristic is often referred to as quantum indeterminacy.

II. BB84 SYSTEM CHARACTERISTICS

Next point is dedicated to the description of the system. To simplify the whole procedure it is assumed that a photon might be polarized in one of four possible directions, i.e. 0, 45, 90 or 135 as depicted below (Fig. 1)
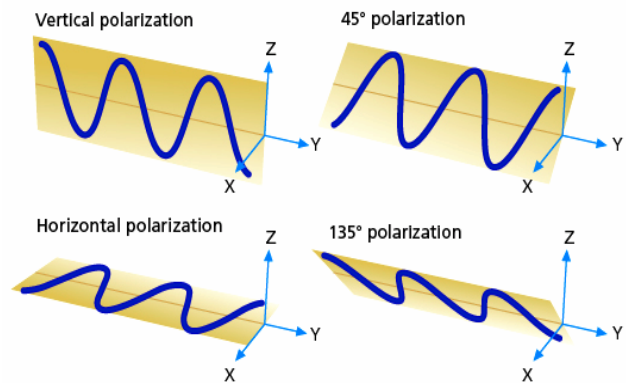
Fig. 1 Possible polarizations of light wave. [9]

Furthermore some convention of bit representation for photon orientations is essential. From the table below it can be observed that if a photon is vertical or 45-tilted then its corresponding binary representation will be 0. Simultaneously all horizontal or 135-tilted photons will be represented by 1.

TABLE 1
SYMBOLIC AND BIT REPRESENTATIONS OF DIFFERENTLY POLARIZED PHOTON IN BB84 PROTOCOL [1]

Polarization	0^0	45^0	90^0	135^0
Symbolic representation	I	/	-	\
Bit representation	0	0	1	1

The whole system must be equipped with two polarization filters. Two pairs of states are used in BB84 protocol and they are always conjugate to each other. States within a single pair are orthogonal to each other and known

as a basis. The commonly used orientations of bases are: rectilinear basis (vertical - 0 and horizontal - 90) and diagonal basis (tilt of 45 and 135).. For clarity, the rectilinear filter is denoted by + and diagonal one by X. A rectilinear filter detects correctly rectilinearly-oriented photons, whereas a diagonal filter diagonally-oriented photons. In other words, whatever the orientation of the photon hitting the filter it will always be detected but in statistically half cases the result will be wrong.

TABLE 2
PHOTON OUTPUTS FOR DIFFERENT INPUT AND FILTER
SCENARIOS IN BB84 PROTOCOL [1]

Input	Filter	Output
\ or /	+	I or -
I or -	X	\ or /

Next step is the thorough description of the algorithm of key exchange itself. Sender, which is proverbial Alice creates a random sequence of bits switching between rectilinear and diagonal bases and sends it to recipient Bob taking notes of state, basis and time of each photon sent. As Bob does not know to which basis the photons coming are polarized he must switch randomly between two types of detectors. For each single photon he takes notes which detector he used and the binary value he obtained for the given detector. After the transmission process is completed Bob needs to inform Alice which detector was used for each single photon. Alice must simply provide him the feedback whether the detector used for a given photon was appropriate to correctly detect the corresponding bit. All bits for which the randomly chosen detector was inappropriate are discarded whereas the remaining bits constitute the key.

To visualize the whole concept we assume that Alice sends only 15 random bits to Bob. Bob has on average 50% chance of choosing the proper detector. For example, if the rectilinear detector is used by Bob and the photon sent is also rectilinearly-oriented the bit will be recorded properly, but if photon was polarized diagonally, its polarization will change and the bit measurement will be incorrect. Bob does not know which particular bits obtained from a choice of wrong detector match Alice's bits and he cannot ask about it as any eavesdropper could very easily intercept the key. Therefore all bits resulted from different choice of detectors must be discarded, despite the fact that approximately half of them would match Alice's bits.

III. BB84 OPERATION AND ITS ANALYSIS IN PRESENCE OF EAVESDROPPER

As it is already known the act of measuring the polarization of a photon may alter the polarization itself. Eavesdropper, proverbial Eve, takes notes of polarization of

photons but simultaneously changes polarization of some of them. Therefore the string of photons that Bob receives may be considerably different from the one sent by Alice. Eve is in the exactly same position as Bob, which means that she is forced to choose detectors randomly. That in turn must result in statistically 50% wrong choice of detector. Still, even having the improper detector chosen, she has got a 50% chance of sending a photon polarized in the way that will yield Bob the bit representation equal to one sent by Alice. Therefore the final error rate on Bob's side after discarding all bits resulted from choice of different detectors by Alice and Bob will be 25%. In this manner both communicating parties will become certain that the channel has been eavesdropped when they will try to use the established key. To understand the idea thoroughly the table below should be investigated:

TABLE 3
ESTABLISHING THE FINAL KEY BETWEEN ALICE AND BOB IN PRESENCE OF
EAVESDROPPER EVE IN BB84 PROTOCOL [1]

Alice's bits	0		1	1	1		0	1			0			
Alice's photons	\	/	\	\	\	\	I	I	\	\	/	I	\	\	/
Good detector	x	x	x	x	x	x	+	+	x	x	x	+	x	x	x
Eve's detector	+	+	x	+	x	x	+	+	x	x	+	x	+	x	x
Eve's photons	I	-	\	I	\	\	I	I	\	\	-	/	-	\	/
Bob's detector	+	x	+	x	x	x	+	x	+	+	+	+	+	+	
Bob's bits	1		1	1	1		0	1			1			

In this example all wrong detectors chosen by Bob and Eve as well as the final bits that became changed because of the act of eavesdropping are denoted in red. As it can be observed, in this sequence of 15 bits 8 of them for which Bob used a wrong detector have been thrown away at once. From the remaining 7 bits a quantum distribution key should be created. However, it turns out that Alice's key differs from Bob's key due to action of eavesdropper, who changed 2 of 7 bits. Alice sends first bit equal to 0 using a diagonal filter, which according to the convention assumed becomes 45-oriented photon. Now, Eve sets the randomly chosen detector for that particular photon, which in this case is a rectilinear one. As quantum indeterminacy implies no possible measurement can distinguish four different polarization states that are not all orthogonal. The only possible measurement is between any two orthogonal states- a basis. That means that when Eve measures in the rectilinear basis it will give her a rectilinearly oriented photon. If this photon had been horizontally or vertically polarized before going through the polarizer the

measurement would have been absolutely correct. Eve is unfortunate as the photon is 45-tilted and thus the rectilinear measurement yields either horizontally or vertically polarized photon with the same probability. Furthermore, all information about the initial polarization of the photon is lost after Eve's measurement. In the case considered the photon becomes horizontally oriented and as such sent to Bob, which uses the detector oriented in the exactly same manner as Alice- diagonally. The horizontally oriented photon passes this detector and must turn into a diagonal orientation, either 45 or 135. In this case Bob receives bit 1, which means that the photon turned into 135 orientation. Summing up Eve by the act of eavesdropping changed the final bit on Bob's side. For the seventh bit in the Alice's final sequence the situation is similar. Eve uses an incorrect detector and it results in incorrect bit received by Bob. For the second bit of Alice's final key the detector used by Eve is again wrongly oriented but the photon passing the Bob's detector become polarized in the way that results in the correct bit representation being 1. For the bits from third to sixth one of Alice's key Eve luckily uses correctly oriented detectors so the polarization of photons will not be altered and Bob will receive correct bits. The final conclusion follows that sender and recipient unable to communicate will have the invaluable information about the potential eavesdropper on the line. Therefore the whole process of key exchange will have to be initialized once again preferably using a different quantum channel.

Next aspect to discuss is the eavesdropping act from Eve's perspective. The only result eavesdropper might obtain is to delay the key exchange and to force both parties to restart the whole procedure. If Eve's sequence of received bits is investigated it results, similarly as in the case of Bob's key when being eavesdropped, in statistically 25% error (a half of all her detectors are wrongly chosen and half of those will change the polarization of a given photon into the one that will be represented by the opposite bit to the original one). Therefore Eve, even knowing which detectors were discarded by Alice and Bob (she may simply eavesdrop their conversation on an open channel), still remains unable to intercept the whole key without any errors and to simultaneously keep her presence hidden. She might also decide to eavesdrop the subsequent conversation related to the establishing the correct detectors. Then her presence will be hidden but will gain no knowledge about the bits from the quantum key as it will be infeasible to calculate fast enough- for a key of n bits she will need to check 2possibilities, which is out of scope in case of real-life communication with long number of bits expressed in thousands.

IV. Practical Considerations and Problems Concerning Quantum Cryptography

Contrary to asymmetric methods of cryptography quantum cryptography is heavily dependent on hardware used. This seems to be the most crucial factor that limits its practical application.

The proper transmission and detection of photons must be satisfied so a precise method of emitting and detecting single photons is indispensable. Photons as very small particles of energy are difficult to be sent separately. By supplying the photon generator with only slightly too much energy several photons might be emitted at once, which is undesirable. Among the techniques proposed for generating single photon states the following are: faint laser pulses, parametric down conversion, single electrons in mesoscopic p-n junctions, photon emission of electron-hole pairs in a semiconductor quantum dot. Except precise emission equipment a detection one is of no less significance. A few possible solutions enabling photon detection exist and those are: photomultipliers, avalanche photo-diodes, multi-channels plates and superconducting Josepheson junctions. Detectors should have a high efficiency over a large spectral range and a short recovery time. Based on those criteria avalanche photo diodes are most advantageous. They operate beyond breakdown voltage of the diode, in a state called Geiger mode. In this mode the energy from a single absorbed photon is enough to cause an electron avalanche, which manifests itself in detectable flood of current. To detect another photon, the diode needs to be reset, which is a time-consuming process and results in detection rate that remains unsatisfactory. Depending on the wavelengths at which detection takes place different semiconductors (silicon, germanium and indium gallium arsenide) may be used.. Unfortunately, silicon has too large band gap so its sensitivity is not sufficient. Best detection wavelength of silicon is 800 nm, whereas at 1100 nm it becomes insensitive, which is still less than standards for telecommunications applications (1300 and 1550 nm). Therefore germanium or indium-gallium-arsenide detectors must be used at telecommunications wavelengths, even though they are far less efficient and must be cooled considerably below room temperature.

Among other factors influencing wider use of quantum cryptography distance of transmission, and dedicated network of fibre lines can be listed. As a medium of transmission fibre optic cables are used most often. Unfortunately their distance of transmission is limited whereas amplifiers cannot be used to send data on the longer distances as they may change the polarization of photons and facilitate the process of eavesdropping. Next trouble encountered concerning fibre lines is their integration with existing optical networks. The cost of building additional optical infrastructure still remains

relatively too high to use quantum cryptography more widely. Furthermore the maintenance of fibre lines is also expensive and if they are not properly protected then a cutting or blocking some part of the network may lead to denial of service, which is unacceptable.

To avoid a use of fibre network an alternative technology might be proposed that is so far still in the stage of preliminary tests and has not been demonstrated yet in practice. Quantum keys are exchanged in this method by means of free space with the aid of satellites. Such transmission is very fluctuating and has got high impedance in comparison with less noisy optical fibre transmission. The communication takes place between a terrestrial station and a low orbit satellite. The absorption of photons in the atmosphere can be minimized using an adequate wavelength. The atmosphere has a high transmission window at a wavelength of about 770 nm, where photons can be easily detected using efficient photon counting modules. At these wavelengths the atmosphere would not change the polarization of photons, which is a great advantage. The type of weather obviously influences the transmission as well. Phase shifts and polarization dependent losses would also have to be taken care of. A satellite obtains the key from the station on the ground, moves with respect to the earth surface and detecting a receiving station sends the key to it.

V. PRACTICAL IMPLEMENTATIONS OF QUANTUM SYSTEMS

BB84 has been experimentally demonstrated to act correctly with bit rate of 1Mbit/s over 20 km and 10 kbit/s over 100 km of fiber optic cable. The most difficult obstacle for transmission of photons in fibre lines over longer distances is the signal strength. Theoretically devices similar to phone repeaters could be used to solve it but their drawback is that they introduce the act of measurement, which is undesirable as potential eavesdropper could take advantage of it. Hopefully, it has been proved by scientists that repeaters that do not perform any detectable measurements are feasible in principle but so far remain a far future prospect. It has been also shown in practice that quantum cryptography system might work over free space for a distance of over one hundred kilometers. Such demonstration was performed twice, first using EC91 protocol and later on with BB84 protocol enhanced with decoy states. In Massachusetts a 10-node quantum cryptography network, called DARPA was implemented in 2004. The first bank transfer with the aid of quantum cryptography was performed in 2004 in Vienna, where 4 years later at a scientific conference a quantum cryptography protected computer network was implemented consisting of 200 km of standard fibre optic cable. Quantum encryption technology was also used in Geneva to transmit ballot results in the national election in 2007.

VI. SUMMARY

To introduce quantum cryptography into wide use a dedicated hardware network must be first precisely built. All the problems related to creating and running such a quantum network trigger off many doubts concerning its profitability. These obstacles also prevent a faster development of quantum protocols and their practical applications. As long as properly implemented asymmetric and hybrid algorithms ensure security, quantum cryptography will remain in the shade. Even though quantum cryptography provides the perfect security guaranteed by the laws of quantum physics, it must first find the effective solutions to all the problems discussed.

REFERENCES

[1] http://zon8.physd.amu.edu.pl/~miran/lectures/optics/wstep.pdf
[2] http://en.wikipedia.org/wiki/BB84
[3] http://en.wikipedia.org/wiki/Quantum_cryptography
[4] http://arxiv.org/ftp/quant-ph/papers/9905/9905009.pdf
[5] V.K., Stanatuis. "Identifying Vulnerabilities of Quantum Cryptography in Secure Optical Data Transport", IEEE Security & Privacy, 2007
[6] R. Tanaś, Wykład z podstaw klasycznej kryptografii z elementami kryptografii kwantowej (http://zon8.physd.amu.edu.pl/~tanas/kryptografia.pdf), Zakład Optyki Nieliniwej, Instytut Fizyki UAM.
[7] Elliott, Chip. "Quantum Cryptography", IEEE Security & Privacy, 2004
[8] http://www.authorstream.com/Presentation/Malden-36580-Introduction-Quantum-Cryptography-List-frequently- asked-questions-Outline-CONVENTIONALCRY-to-as-Entertainment-ppt-powerpoint
[9] http://www.nikon.com/about/feelnikon/light/chap04/sec01.htm

Wojciech Zabierowski (Assistant Professor at Department of Microelectronic and Computer Science Technical University of Lodz) was born in Lodz, Poland, on April 9, 1975. He received the M.Sc. and Ph.D. degrees from the Technical University of Lodz in 1999 and 2008, respectively. He is an author or co-author of more than 70 publications: journals and most of them - papers in international conference proceedings. He was reviewer in six international conferences. He supervised more than 90 Msc theses. He is focused on internet technologies and automatic generation of music. He is working in linguistic analysis of musical structure.

Methods of Sound Data Compression – Comparison of Different Standards

Norbert Nowak, Wojciech Zabierowski

Abstract — **The following article is about the methods of sound data compression. The technological progress has facilitated the process of recording audio on different media such as CD-Audio. The development of audio data compression has significantly made our lives easier. In recent years, much has been achieved in the field of audio and speech compression. Many standards have been established. They are characterized by more better sound quality at lower bitrate. It allows to record the same CD-Audio formats using "lossy" or lossless compression algorithms in order to reduce the amount of data surface area at almost noticeable difference in the quality of the recording. In order to compare methods of sound data compression I have used Adobe Audition 3.0 software and computer program of the sound compression system from manufacturers' side. To illustrate the problem, I have used the graphs of the spectrum and musical composition spectrograms. The comparison has been done on the basis of uncompressed music track from the original CD-Audio.**

Index Terms—**sound data compression, mp3, FLAC, comparison.**

I. INTRODUCTION

NOWADAYS, it is possible to store audio data on various media such as hard drive or portable flash memory. Due to the technological progress, it has been noticed that the audio data takes up too much memory space. Moreover, it has been stated that if various data can be compressed, it is also possible to diminish audio files without much loss in quality by rejecting unwanted frequencies, inaudible to human ears.

Placing various audio files without using compression algorithms on the Internet would be useless. What is more cell phones without compression are not capable of communication in better quality. It is noticeable how fast the data compression has become ubiquitous in our lives and yet it has been an interest of only small group of engineers and scientists for many years.

Data compression is a change of recording information in such a way to reduce the volume of the collection.

Therefore, it is a shift of the same set of information using fewer bits. The use of compression can be found in multimedia devices, DVD movies, digital television, data transmission, the Internet, etc.

II. DEFINITION

Modeling and coding

One's requirements decide what type of compression he applies. However, the choice between lossy or lossless method also depends on other factors. One of the most important is the characteristics of data that will be compressed. For instance, the same algorithm, which effectively compresses the text may be completely useless in the case of video and sound compression.

It is worth remembering that compression is an experimental science. The best option is chosen depending on the nature of the redundancy present in the data. Designing of algorithms' compression for different data is divided into two stages. The first stage is called modeling. Due to this, the information of any redundancy occurring in the data is described by a model. The next step is encoding the description of the model and the description that informs about the differences in data related to the model. This process is done by using the binary alphabet. The dissimilarity between data and the model is called a deviation (Fig. 1).
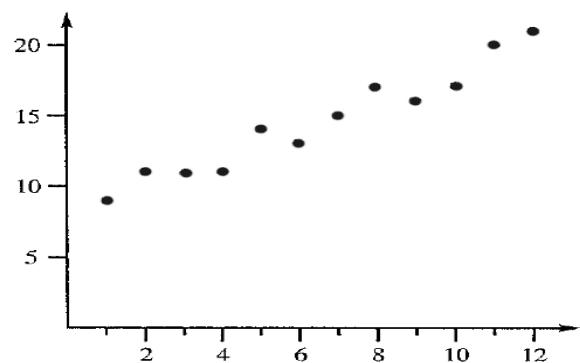

Fig. 1 String data

Lossless compression algorithms

Lossless data compression is does not allow the loss of information. There are certain types of files that can be compressed only by lossless method. This data must be accurately opened later in the process of decompression such as text files, program code files or audio and image files in professional applications. If the text data is compressed by lossy method, it would cause a loss of some information, namely the adverse and unexpected effect of letter substitution, mistakes in words, or even dropping entire sentences. Also audio data for professional applications, where the sound is often subjected to subsequent treatment, requires the staunchest reconstruction after decompression. Moreover, there is data that is difficult or even impossible to compress, such as streams of random numbers, or the data already compressed using the same algorithm.

A lossless compression algorithm handles the data correctly, where there is redundancy of information. The most commonly used methods are vocabulary that find occurrences of the string and replace the shorter number of bits than is needed to encode and statistical that use fewer bits for repeatedly occurring symbols. It is obvious that there are many situations where it is necessary to use compression to ensure that the data before and after decompression (reconstruction) is identical.

Lossy compression algorithms

Lossy compression reduces the number of bits needed to express a particular information. Reconstructed information usually is not identical to the original. There is some loss of information and distortion. However, a better compression ratio is gained than in lossless compression. An inability of an exact reconstruction is not an obstacle. In some applications this is not a must, for example sending the speech signal does not require the exact value of each sample. Assuming a certain quality of reconstruction, diverse distortions and differences in relation to the original are allowed. If, for instance, the speech quality signal has to be the phone quality, some loss of information can be permitted. When there is a need to receive the speech signal of CD quality, some loss of information (relatively small) is also acceptable.

While designing algorithms for lossy compression, some methods are needed to measure its quality. Due to the different areas of applications, a number of concepts has been introduced to describe and measure the compression quality.

Measures of quality compression

Compression algorithms can be assessed using different criteria, for example, measuring the complexity of the algorithm, speed of action, memory, which is required for the algorithm implementation , the degree of compression and data similarity after decompression to the original data.

The degree of compression is a measure of how effectively an algorithm can be compressed. It is the ratio of the number of bits needed to represent the data before compression to the number of bits that is needed to represent data after the process.

Using a lossy compression, the data obtained after decompression differ from the original. To determine the effectiveness of the algorithm, some ways are needed to measure these differences. Such differences are called the distortion. Lossy compression is usually used to compress data, which originally took the form of the analog, for instance audio, video sequence. Encoding analog signal is often referred to as a continuous wavelet encoding.

The ultimate arbiter, that can assess the quality of sound signal waveform encoding, is a man. Due to the fact that such assessments are difficult to reproduce mathematically, some models are applied. One of these schemes is the psycholinguistic model. Further terms such as fidelity and quality are used to detect differences between the original and decompressed signal. If the fidelity or quality of decompression (reconstruction) is large, it means that such data does not differ significantly from the original data.

III. ANALYSIS AND COMPARISON OF AUDIO DATA COMPRESSION STANDARDS

In my analysis I used four systems of lossy compression and two of lossless compression. I have compared every described standard with the uncompressed source file, deriving from the original CD. I have based my analysis of selected files on a specific criterion. I took into account the psychoacoustic qualities, therefore a human hearing.

For the study I have used Adobe Audition 3.0. demo version that is a professional music program for processing and analysis of an audio sound. The results are presented using the two most important tools: a graph showing the spectrum of acoustic signal (Fig. 2) and the spectrogram that is the signal amplitude spectrum diagram (Fig. 3).

The main problem in lossy compression systems was weak transfer of high frequencies. This effect occurred at lower data rates because the algorithms use the filters, which cut the high frequency band depending on the bandwidth, such as 16kHz upwards. The lower the rate, the less bandwidth system offers us.

The best lossy compression system has turned out to be little known Musepack, offering exemplary sound quality at 210kbps bit rate. As far as lossless compression is concerned, Monkey's Audio has been the top-quality system offering comperssion grade of 67.39%.
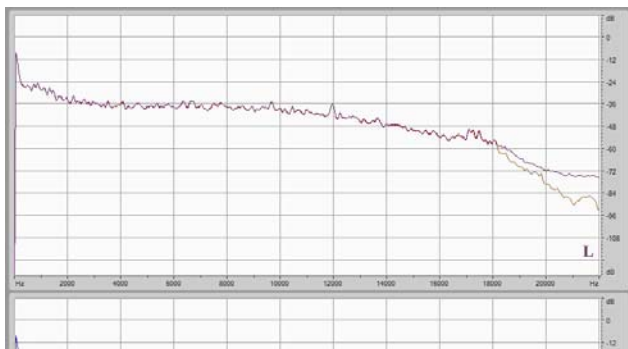
Fig. 2. The spectrum of a musical composition after applying MP3 compression at 320kbps
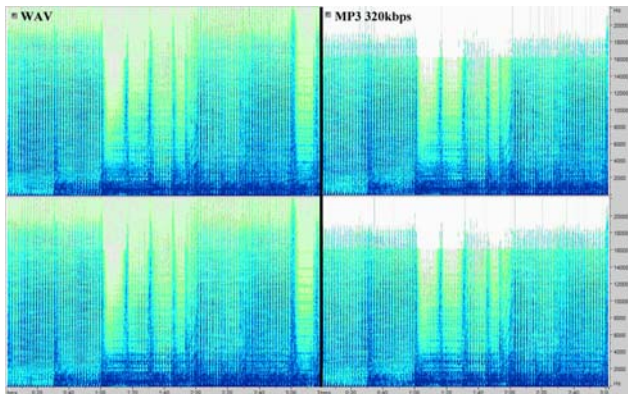

Fig. 3. Spectrogram of a musical composition after applying MP3 compression at 320 kbps

The following table shows the results of compression using chosen standards that apply lossy compression. Comparative criterion is the degree of compression, the compressed file size and sound quality after compression of the original WAV file size 64.1 MB (Table 1).

Next table presents the results of compression using given standards that apply lossless compression. In this case, the comparison criterion is the degree of compression and file size after compression of the original WAV file size 64.1 MB. The sound quality after decompression in all cases is the same, consistent with the original (Table 2).

TABLE 1
COMPRESSION USING CHOSEN STANDARDS THAT APPLY LOSSY COMPRESSION

Compression system	Compression ratio	Compressed size	Sound quality
MP3 320 kbps	22,62%	14,5 MB	very good
MP3 128 kbps	9%	5,81 MB	good
MP3 96 kbps	6,79%	4,35 MB	low
WMA 320 kbps	22,62%	14,5 MB	very good
WMA 128 kbps	9,13%.	5,85 MB	good
WMA 96 kbps	6,86%	4.4 MB	low
Ogg Vorbis 320 kbps	22,78%.	14,6 MB	high
Ogg Vorbis 128 kbps	9,2%	5,9 MB	very good
Ogg Vorbis 96 kbps	6,9%	4,42 MB	good
Ogg Vorbis 64 kbps	4,6%	2,95 MB	low
Musepack 210 kbps	15%	9,62 MB	high
Musepack 180 kbps	12,8%	8,22 MB	very good
Musepack 130 kbps	9,6%	6,18 MB	good
Musepack 90 kbps	6,72%	4.31 MB	acceptable

TABLE 2
COMPRESSION USING GIVEN STANDARDS THAT APPLY LOSSLESS COMPRESSION

Compression system	Compression ratio	Compressed size
Monkey's Audio tryb "Extra High"	67,39%	43,2MB
Monkey's Audio tryb "High"	67,86%	43,5MB
Monkey's Audio tryb "Normal"	68,02%	43,6MB
Monkey's Audio tryb "Fast"	69,89%	44,8MB
FLAC tryb "8"	69,58%	44,6MB
FLAC tryb "5"	70,20%	45,0MB
FLAC tryb "0"	75,19%	48,2MB

IV. SUMMARY

Over the past year, a lot of achievements have been made in the field of audio and speech compression. Many standards have been created that are characterized by increasingly higher sound quality at lower data rates. Their efficiency and capabilities have increased significantly. A big space of available memory gives a possibility to save a huge amount of music compressed by different codecs using a lossy method, such as MP3, WMA, Musepack, and lossless method, such as increasingly popular standard for FLAC. Indeed, without compression large amounts of audio data could be moved. However, by using the compression, saving the data is 10 times more efficient with a slight, almost imperceptible loss of quality.

After this analysis, I conclude that using the audio compression that uses systems applying the lossless compression, allows to reduce the audio data without any loss in quality by 30%. In this way a perfect copy of the original is received. Using lossy compression schemes, one can obtain the file size of about 90% smaller than the original, with an appreciable loss of quality. Thus obtained files, thanks to their small size, suit perfectly for transmission over the Internet. The second option is to get the file decreased about 80% with obtaining high-quality music recording, with no noticeable differences by an average listener.

REFERENCES

[1] K. Sayood, Data compression. Introduction, Publisher RM, Warsaw 2002
[2] A. Krupiczka, Multimedia: compression algorithms and standards / edited by Wladyslaw Skarbek, Academic Publishing House PLJ, Warsaw 1998
[3] W. Buryn, Digital audio. Multichannel Systems, WKiŁ, Warsaw 2004
[4] www.naukowy.pl

Wojciech Zabierowski (Assistant Professor at Department of Microelectronic and Computer Science Technical University of Lodz) was born in Lodz, Poland, on April 9, 1975. He received the M.Sc. and Ph.D. degrees from the Technical University of Lodz in 1999 and 2008, respectively. He is an author or co-author of more than 70 publications: journals and most of them - papers in international conference proceedings. He was reviewer in six international conferences. He supervised more than 90 Msc theses. He is focused on internet technologies and automatic generation of music. He is working in linguistic analysis of musical structure.

Preparation of Papers for IEEE TRANSACTIONS and JOURNALS

First A. Author, Second B. Author, Jr., and Third C. Author, *Member, IEEE*

Abstract—**These instructions give you guidelines for preparing papers for IEEE TRANSACTIONS and JOURNALS. Use this document as a template if you are using Microsoft *Word* 6.0 or later. Otherwise, use this document as an instruction set. The electronic file of your paper will be formatted further at IEEE. Define all symbols used in the abstract. Do not cite references in the abstract. Do not delete the blank line immediately above the abstract; it sets the footnote at the bottom of this column.**

Index Terms—**About four key words or phrases in alphabetical order, separated by commas. For a list of suggested keywords, send a blank e-mail to keywords@ieee.org or visit http://www.ieee.org/organizations/pubs/ani_prod/keywrd98.txt**

I. INTRODUCTION

THIS document is a template for Microsoft *Word* versions 6.0 or later. If you are reading a paper or PDF version of this document, please download the electronic file, TRANS-JOUR.DOC, from the IEEE Web site at http://www.ieee.org/web/publications/authors/transjnl/index.html so you can use it to prepare your manuscript. If you would prefer to use LATEX, download IEEE's LATEX style and sample files from the same Web page. Use these LATEX files for formatting, but please follow the instructions in TRANS-JOUR.DOC or TRANS-JOUR.PDF.

If your paper is intended for a *conference,* please contact your conference editor concerning acceptable word processor formats for your particular conference.

When you open TRANS-JOUR.DOC, select "Page Layout" from the "View" menu in the menu bar (View | Page Layout), which allows you to see the footnotes. Then, type over sections of TRANS-JOUR.DOC or cut and paste from another document and use markup styles. The pull-down style menu is at the left of the Formatting Toolbar at the top of your *Word* window (for example, the style at this point in the document is "Text"). Highlight a section that you want to designate with a certain style, then select the appropriate name on the style menu. The style will adjust your fonts and line spacing. **Do not change the font sizes or line spacing to squeeze more text into a limited number of pages.** Use italics for emphasis; do not underline.

To insert images in *Word,* position the cursor at the insertion point and either use Insert | Picture | From File or copy the image to the Windows clipboard and then Edit | Paste Special | Picture (with "float over text" unchecked).

IEEE will do the final formatting of your paper. If your paper is intended for a conference, please observe the conference page limits.

II. PROCEDURE FOR PAPER SUBMISSION

A. Review Stage

Please check with your editor on whether to submit your manuscript as hard copy or electronically for review. If hard copy, submit photocopies such that only one column appears per page. This will give your referees plenty of room to write comments. Send the number of copies specified by your editor (typically four). If submitted electronically, find out if your editor prefers submissions on disk or as e-mail attachments.

If you want to submit your file with one column electronically, please do the following:

--First, click on the View menu and choose Print Layout.

--Second, place your cursor in the first paragraph. Go to the Format menu, choose Columns, choose one column Layout, and choose "apply to whole document" from the dropdown menu.

--Third, click and drag the right margin bar to just over 4 inches in width.

F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (corresponding author to provide phone: 303-555-5555; fax: 303-555-5555; e-mail: author@ boulder.nist.gov).

S. B. Author, Jr., was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA (e-mail: author@lamar.colostate.edu).

T. C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

The graphics will stay in the "second" column, but you can drag them to the first column. Make the graphic wider to push out any text that may try to fill in next to the graphic.

B. Final Stage

When you submit your final version (after your paper has been accepted), print it in two-column format, including figures and tables. You must also send your final manuscript on a disk, via e-mail, or through a Web manuscript submission system as directed by the society contact. You may use *Zip* or CD-ROM disks for large files, or compress files using *Compress, Pkzip, Stuffit,* or *Gzip.*

Also, send a sheet of paper or PDF with complete contact information for all authors. Include full mailing addresses, telephone numbers, fax numbers, and e-mail addresses. This information will be used to send each author a complimentary copy of the journal in which the paper appears. In addition, designate one author as the "corresponding author." This is the author to whom proofs of the paper will be sent. Proofs are sent to the corresponding author only.

C. Figures

Format and save your graphic images using a suitable graphics processing program that will allow you to create the images as PostScript (PS), Encapsulated PostScript (EPS), or Tagged Image File Format (TIFF), sizes them, and adjusts the resolution settings. If you created your source files in one of the following you will be able to submit the graphics without converting to a PS, EPS, or TIFF file: Microsoft Word, Microsoft PowerPoint, Microsoft Excel, or Portable Document Format (PDF).

D. Electronic Image Files (Optional)

Import your source files in one of the following: Microsoft Word, Microsoft PowerPoint, Microsoft Excel, or Portable Document Format (PDF); you will be able to submit the graphics without converting to a PS, EPS, or TIFF files. Image quality is very important to how yours graphics will reproduce. Even though we can accept graphics in many formats, we cannot improve your graphics if they are poor quality when we receive them. If your graphic looks low in quality on your printer or monitor, please keep in mind that cannot improve the quality after submission.

If you are importing your graphics into this Word template, please use the following steps:

Under the option EDIT select PASTE SPECIAL. A dialog box will open, select paste picture, then click OK. Your figure should now be in the Word Document.

If you are preparing images in TIFF, EPS, or PS format, note the following. High-contrast line figures and tables should be prepared with 600 dpi resolution and saved with no compression, 1 bit per pixel (monochrome), with file names in the form of "fig3.tif" or "table1.tif."

Photographs and grayscale figures should be prepared with 300 dpi resolution and saved with no compression, 8 bits per pixel (grayscale).

Sizing of Graphics

Most charts graphs and tables are one column wide (3 1/2 inches or 21 picas) or two-column width (7 1/16 inches, 43 picas wide). We recommend that you avoid sizing figures less than one column wide, as extreme enlargements may distort your images and result in poor reproduction. Therefore, it is better if the image is slightly larger, as a minor reduction in size should not have an adverse affect the quality of the image.

Size of Author Photographs

The final printed size of an author photograph is exactly 1 inch wide by 1 1/4 inches long (6 picas × 7 1/2 picas). Please ensure that the author photographs you submit are proportioned similarly. If the author's photograph does not appear at the end of the paper, then please size it so that it is proportional to the standard size of 1 9/16 inches wide by 2 inches long (9 1/2 picas × 12 picas). JPEG files are only accepted for author photos.

How to create a PostScript File

First, download a PostScript printer driver from http://www.adobe.com/support/downloads/pdrvwin.htm (for Windows) or from http://www.adobe.com/support/downloads/ pdrvmac.htm (for Macintosh) and install the "Generic PostScript Printer" definition. In *Word,* paste your figure into a new document. Print to a file using the PostScript printer driver. File names should be of the form "fig5.ps." Use Open Type fonts when creating your figures, if possible. A listing of the acceptable fonts are as follows: Open Type Fonts: Times Roman, Helvetica, Helvetica Narrow, Courier, Symbol, Palatino, Avant Garde, Bookman, Zapf Chancery, Zapf Dingbats, and New Century Schoolbook.

Print Color Graphics Requirements

IEEE accepts color graphics in the following formats: EPS, PS, TIFF, Word, PowerPoint, Excel, and PDF. The resolution of a RGB color TIFF file should be 400 dpi.

When sending color graphics, please supply a high quality hard copy or PDF proof of each image. If we cannot achieve a satisfactory color match using the electronic version of your files, we will have your hard copy scanned. Any of the files types you provide will be converted to RGB color EPS files.
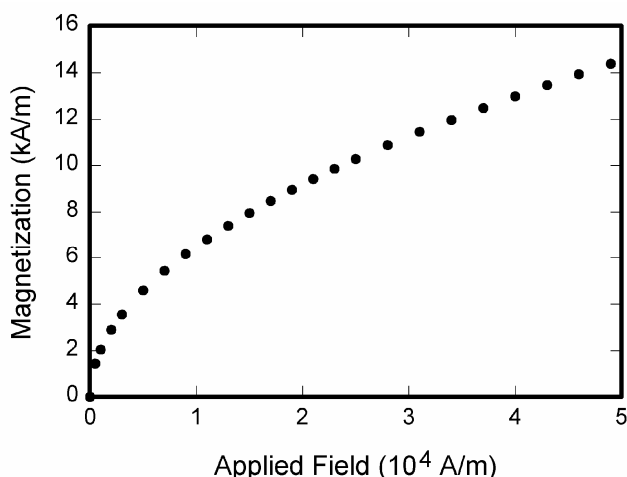
Fig. 1. Magnetization as a function of applied field. Note that "Fig." is abbreviated. There is a period after the figure number, followed by two spaces. It is good practice to explain the significance of the figure in the caption.

Web Color Graphics

IEEE accepts color graphics in the following formats: EPS, PS, TIFF, Word, PowerPoint, Excel, and PDF. The resolution of a RGB color TIFF file should be at least 400 dpi.

Your color graphic will be converted to grayscale if no separate grayscale file is provided. If a graphic is to appear in print as black and white, it should be saved and submitted as a black and white file. If a graphic is to appear in print or on IEEE Xplore in color, it should be submitted as RGB color.

Graphics Checker Tool

The IEEE Graphics Checker Tool enables users to check graphic files. The tool will check journal article graphic files against a set of rules for compliance with IEEE requirements. These requirements are designed to ensure sufficient image quality so they will look acceptable in print. After receiving a graphic or a set of graphics, the tool will check the files against a set of rules. A report will then be e-mailed listing each graphic and whether it met or failed to meet the requirements. If the file fails, a description of why and instructions on how to correct the problem will be sent. The IEEE Graphics Checker Tool is available at http://graphicsqc.ieee.org/

For more Information, contact the IEEE Graphics H-E-L-P Desk by e-mail at graphics@ieee.org. You will then receive an e-mail response and sometimes a request for a sample graphic for us to check.

E. Copyright Form

An IEEE copyright form should accompany your final submission. You can get a .pdf, .html, or .doc version at http://www.ieee.org/copyright. Authors are responsible for

TABLE I
UNITS FOR MAGNETIC PROPERTIES

Symbol	Quantity	Conversion from Gaussian and CGS EMU to SI [a]
Φ	magnetic flux	$1 \text{ Mx} \to 10^{-8} \text{ Wb} = 10^{-8} \text{ V·s}$
B	magnetic flux density, magnetic induction	$1 \text{ G} \to 10^{-4} \text{ T} = 10^{-4} \text{ Wb/m}^2$
H	magnetic field strength	$1 \text{ Oe} \to 10^3/(4\pi) \text{ A/m}$
m	magnetic moment	$1 \text{ erg/G} = 1 \text{ emu}$ $\to 10^{-3} \text{ A·m}^2 = 10^{-3} \text{ J/T}$
M	magnetization	$1 \text{ erg/(G·cm}^3) = 1 \text{ emu/cm}^3$ $\to 10^3 \text{ A/m}$
$4\pi M$	magnetization	$1 \text{ G} \to 10^3/(4\pi) \text{ A/m}$
σ	specific magnetization	$1 \text{ erg/(G·g)} = 1 \text{ emu/g} \to 1 \text{ A·m}^2/\text{kg}$
j	magnetic dipole moment	$1 \text{ erg/G} = 1 \text{ emu}$ $\to 4\pi \times 10^{-10} \text{ Wb·m}$
J	magnetic polarization	$1 \text{ erg/(G·cm}^3) = 1 \text{ emu/cm}^3$ $\to 4\pi \times 10^{-4} \text{ T}$
χ, κ	susceptibility	$1 \to 4\pi$
χ_ρ	mass susceptibility	$1 \text{ cm}^3/\text{g} \to 4\pi \times 10^{-3} \text{ m}^3/\text{kg}$
μ	permeability	$1 \to 4\pi \times 10^{-7} \text{ H/m}$ $= 4\pi \times 10^{-7} \text{ Wb/(A·m)}$
μ_r	relative permeability	$\mu \to \mu_r$
w, W	energy density	$1 \text{ erg/cm}^3 \to 10^{-1} \text{ J/m}^3$
N, D	demagnetizing factor	$1 \to 1/(4\pi)$

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

[a]Gaussian units are the same as cgs emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

obtaining any security clearances.

III. MATH

If you are using *Word,* use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). "Float over text" should *not* be selected.

IV. UNITS

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary units (in parentheses). **This applies to papers in data storage.** For example, write "15 Gb/cm^2 (100 Gb/in^2)." An exception is when English units are used as identifiers in trade, such as "3½-in disk drive." Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as $\mu_0 H$. Use the center dot to separate compound units, e.g., "A·m^2."

V. Helpful Hints

A. Figures and Tables

Because IEEE will do the final formatting of your paper, you do not need to position figures and tables at the top and bottom of each column. In fact, all figures, figure captions, and tables can be at the end of the paper. Large figures and tables may span both columns. Place figure captions below the figures; place table titles above the tables. If your figure has two parts, include the labels "(a)" and "(b)" as part of the artwork. Please verify that the figures and tables you mention in the text actually exist. **Please do not include captions as part of the figures. Do not put captions in "text boxes" linked to the figures. Do not put borders around the outside of your figures.** Use the abbreviation "Fig." even at the beginning of a sentence. Do not abbreviate "Table." Tables are numbered with Roman numerals.

Color printing of figures is available, but is billed to the authors. Include a note with your final paper indicating that you request and will pay for color printing. Do not use color unless it is necessary for the proper interpretation of your figures. If you want reprints of your color article, the reprint order should be submitted promptly. There is an additional charge for color reprints. **Please note that many IEEE journals now allow an author to publish color figures on Xplore and black and white figures in print. Contact your society representative for specific requirements.**

Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity "Magnetization," or "Magnetization M," not just "M." Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write "Magnetization (A/m)" or "Magnetization $(A \cdot m^{-1})$," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization $(10^3$ A/m)." Do not write "Magnetization (A/m) $\times$ 1000" because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 12 point type.

B. References

Number citations consecutively in square brackets [1]. The sentence punctuation follows the brackets [2]. Multiple references [2], [3] are each numbered with separate brackets [1]–[3]. When citing a section in a book, please give the relevant page numbers [2]. In sentences, refer simply to the reference number, as in [3]. Do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] shows ... ." Please do not use automatic endnotes in *Word*, rather, type the reference list at the end of the paper using the "References" style.

Number footnotes separately in superscripts (Insert | Footnote).[1] Place the actual footnote at the bottom of the column in which it is cited; do not put footnotes in the reference list (endnotes). Use letters for table footnotes (see Table I).

Please note that the references at the end of this document are in the preferred referencing style. Give all authors' names; do not use "*et al.*" unless there are six authors or more. Use a space after authors' initials. Papers that have not been published should be cited as "unpublished" [4]. Papers that have been accepted for publication, but not yet specified for an issue should be cited as "to be published" [5]. Papers that have been submitted for publication should be cited as "submitted for publication" [6]. Please give affiliations and addresses for private communications [7].

Capitalize only the first word in a paper title, except for proper nouns and element symbols. For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [8].

C. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S." Do not use abbreviations in the title unless they are unavoidable (for example, "IEEE" in the title of this article).

D. Equations

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the "Equation" markup style. Press the tab key and write the equation number in parentheses. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

$$\int_0^{r_2} F(r,\varphi) \, dr \, d\varphi = [\sigma r_2 / (2\mu_0)]$$
$$\cdot \int_0^{\infty} \exp(-\lambda |z_j - z_i|) \lambda^{-1} J_1(\lambda r_2) J_0(\lambda r_i) \, d\lambda .$$
$$(1)$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (T might refer to temperature,

---

[1]It is recommended that footnotes be avoided (except for the unnumbered footnote with the receipt date on the first page). Instead, try to integrate the footnote information into the text.

but T is the unit tesla). Refer to "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ... ."

E. Other Recommendations

Use one space after periods and colons. Hyphenate complex modifiers: "zero-field-cooled magnetization." Avoid dangling participles, such as, "Using (1), the potential was calculated." [It is not clear who or what used (1).] Write instead, "The potential was calculated by using (1)," or "Using (1), we calculated the potential."

Use a zero before decimal points: "0.25," not ".25." Use "cm^3," not "cc." Indicate sample dimensions as "0.1 cm $\times$ 0.2 cm," not "0.1 $\times$ 0.2 cm^2." The abbreviation for "seconds" is "s," not "sec." Do not mix complete spellings and abbreviations of units: use "Wb/m^2" or "webers per square meter," not "$webers/m^2$." When expressing a range of values, write "7 to 9" or "7-9," not "7~9."

A parenthetical statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.) In American English, periods and commas are within quotation marks, like "this period." Other punctuation is "outside"! Avoid contractions; for example, write "do not" instead of "don't." The serial comma is preferred: "A, B, and C" instead of "A, B and C."

If you wish, you may write in the first person singular or plural and use the active voice ("I observed that ..." or "We observed that ..." instead of "It was observed that ..."). Remember to check spelling. If your native language is not English, please get a native English-speaking colleague to carefully proofread your paper.

VI. Some Common Mistakes

The word "data" is plural, not singular. The subscript for the permeability of vacuum μ_0 is zero, not a lowercase letter "o." The term for residual magnetization is "remanence"; the adjective is "remanent"; do not write "remnance" or "remnant." Use the word "micrometer" instead of "micron." A graph within a graph is an "inset," not an "insert." The word "alternatively" is preferred to the word "alternately" (unless you really mean something that alternates). Use the word "whereas" instead of "while" (unless you are referring to simultaneous events). Do not use the word "essentially" to mean "approximately" or "effectively." Do not use the word "issue" as a euphemism for "problem." When compositions are not specified, separate chemical symbols by en-dashes; for example, "NiMn" indicates the intermetallic compound $Ni_{0.5}Mn_{0.5}$ whereas "Ni–Mn" indicates an alloy of some composition Ni_xMn_{1-x}.

Be aware of the different meanings of the homophones "affect" (usually a verb) and "effect" (usually a noun), "complement" and "compliment," "discreet" and "discrete," "principal" (e.g., "principal investigator") and "principle" (e.g., "principle of measurement"). Do not confuse "imply" and "infer."

Prefixes such as "non," "sub," "micro," "multi," and "ultra" are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the "et" in the Latin abbreviation "*et al.*" (it is also italicized). The abbreviation "i.e.," means "that is," and the abbreviation "e.g.," means "for example" (these abbreviations are not italicized).

An excellent style manual and source of information for science writers is [9]. A general IEEE style guide and an *Information for Authors* are both available at http://www.ieee.org/web/publications/authors/transjnl/index.html

VII. Editorial Policy

Submission of a manuscript is not required for participation in a conference. Do not submit a reworked version of a paper you have submitted or published elsewhere. Do not publish "preliminary" data or results. The submitting author is responsible for obtaining agreement of all coauthors and any consent required from sponsors before submitting a paper. IEEE Transactions and Journals strongly discourage courtesy authorship. It is the obligation of the authors to cite relevant prior work.

The Transactions and Journals Department does not publish conference records or proceedings. The Transactions does publish papers related to conferences that have been recommended for publication on the basis of peer review. As a matter of convenience and service to the technical community, these topical papers are collected and published in one issue of the Transactions.

At least two reviews are required for every paper submitted. For conference-related papers, the decision to accept or reject a paper is made by the conference editors and publications committee; the recommendations of the referees are advisory only. Undecipherable English is a valid reason for rejection. Authors of rejected papers may revise and resubmit them to the Transactions as regular papers, whereupon they will be reviewed by two new referees.

VIII. Publication Principles

The contents of IEEE Transactions and Journals are peer-reviewed and archival. The Transactions publishes scholarly articles of archival value as well as tutorial expositions and critical reviews of classical subjects and topics of current interest.

Authors should consider the following points:
1) Technical papers submitted for publication must advance the state of knowledge and must cite relevant prior work.
2) The length of a submitted paper should be commensurate with the importance, or appropriate to

the complexity, of the work. For example, an obvious extension of previously published work might not be appropriate for publication or might be adequately treated in just a few pages.

3) Authors must convince both peer reviewers and the editors of the scientific and technical merit of a paper; the standards of proof are higher when extraordinary or unexpected results are reported.

4) Because replication is required for scientific progress, papers submitted for publication must provide sufficient information to allow readers to perform similar experiments or calculations and use the reported results. Although not everything need be disclosed, a paper must contain new, useable, and fully described information. For example, a specimen's chemical composition need not be reported if the main purpose of a paper is to introduce a new measurement technique. Authors should expect to be challenged by reviewers if the results are not supported by adequate data and critical details.

5) Papers that describe ongoing work or announce the latest technical achievement, which are suitable for presentation at a professional conference, may not be appropriate for publication in a TRANSACTIONS or JOURNAL.

IX. CONCLUSION

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks ... ." **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.**

REFERENCES

[1] G. O. Young, "Synthetic structure of industrial plastics (Book style with paper title and editor)," in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.

[2] W.-K. Chen, *Linear Networks and Systems* (Book style)*.* Belmont, CA: Wadsworth, 1993, pp. 123–135.

[3] H. Poor, *An Introduction to Signal Detection and Estimation*. New York: Springer-Verlag, 1985, ch. 4.

[4] B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.

[5] E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," *IEEE Trans. Antennas Propagat.*, to be published.

[6] J. Wang, "Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication)," *IEEE J. Quantum Electron.*, submitted for publication.

[7] C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.

[8] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces (Translation Journals style)," *IEEE Transl. J. Magn.Jpn.*, vol. 2, Aug. 1987, pp. 740–741 [*Dig. 9th Annu. Conf. Magnetics* Japan, 1982, p. 301].

[9] M. Young, *The Techincal Writers Handbook*. Mill Valley, CA: University Science, 1989.

[10] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility (Periodical style)," *IEEE Trans. Electron Devices*, vol. ED-11, pp. 34–39, Jan. 1959.

[11] S. Chen, B. Mulgrew, and P. M. Grant, "A clustering technique for digital communications channel equalization using radial basis function networks," *IEEE Trans. Neural Networks*, vol. 4, pp. 570–578, Jul. 1993.

[12] R. W. Lucky, "Automatic equalization for digital communication," *Bell Syst. Tech. J.*, vol. 44, no. 4, pp. 547–588, Apr. 1965.

[13] S. P. Bingulac, "On the compatibility of adaptive controllers (Published Conference Proceedings style)," in *Proc. 4th Annu. Allerton Conf. Circuits and Systems Theory*, New York, 1994, pp. 8–16.

[14] G. R. Faulhaber, "Design of service systems with priority reservation," in *Conf. Rec. 1995 IEEE Int. Conf. Communications,* pp. 3–8.

[15] W. D. Doyle, "Magnetization reversal in films with biaxial anisotropy," in *1987 Proc. INTERMAG Conf.*, pp. 2.2-1–2.2-6.

[16] G. W. Juette and L. E. Zeffanella, "Radio noise currents n short sections on bundle conductors (Presented Conference Paper style)," presented at the IEEE Summer power Meeting, Dallas, TX, Jun. 22–27, 1990, Paper 90 SM 690-0 PWRS.

[17] J. G. Kreifeldt, "An analysis of surface-detected EMG as an amplitude-modulated noise," presented at the 1989 Int. Conf. Medicine and Biological Engineering, Chicago, IL.

[18] J. Williams, "Narrow-band analyzer (Thesis or Dissertation style)," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.

[19] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

[20] J. P. Wilkinson, "Nonlinear resonant circuit devices (Patent style)," U.S. Patent 3 624 12, July 16, 1990.

[21] *IEEE Criteria for Class IE Electric Systems* (Standards style)*,* IEEE Standard 308, 1969.

[22] *Letter Symbols for Quantities*, ANSI Standard Y10.5-1968.

[23] R. E. Haskell and C. T. Case, "Transient signal propagation in lossless isotropic plasmas (Report style)," USAF Cambridge Res. Lab., Cambridge, MA Rep. ARCRL-66-234 (II), 1994, vol. 2.

[24] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the Earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (420-46)-3, Nov. 1988.

[25] (Handbook style) *Transmission Systems for Communications,* 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44–60.

[26] *Motorola Semiconductor Data Manual,* Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

[27] (Basic Book/Monograph Online Sources) J. K. Author. (year, month, day). *Title* (edition) [Type of medium]. Volume (issue). Available: http://www.(URL)

[28] J. Jones. (1991, May 10). Networks (2nd ed.) [Online]. Available: http://www.atm.com

[29] (Journal Online Sources style) K. Author. (year, month). Title. *Journal* [Type of medium]. Volume(issue), paging if given. Available: http://www.(URL)

[30] R. J. Vidmar. (1992, August). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. *21(3).* pp. 876–880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

First A. Author (M'76–SM'81–F'87) and the other authors may include biographies at the end of regular papers. Biographies are often not included in conference-related papers. This author became a Member (M) of IEEE in 1976, a Senior Member (SM) in 1981, and a Fellow (F) in 1987. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state, and country, and year degree was earned. The author's major field of study should be lower-cased.

The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (city, state: publisher name, year) similar to a reference. Current and previous research interests end the paragraph.

The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, the biography will be indented around it. The photograph is placed at the top left of the biography. Personal hobbies will be deleted from the biography.