2013

Proceedings of IXth International Conference on Perspective Technologies and Methods in MEMS Design

16-20 April 2013
Polyana, Ukraine

Lviv Polytechnic National University

Міністерство освіти і науки
Національний університет «Львівська політехніка»

ПЕРСПЕКТИВНІ ТЕХНОЛОГІЇ І МЕТОДИ ПРОЕКТУВАННЯ МЕМС

Матеріали
дев'ятої Міжнародної конференції
MEMSTECH 2013

16-20 квітня 2013
Поляна, Україна

Львів
Видавництво Львівської політехніки
2013

ББК 32.965.3
П279
УДК 681.52

Organised by:

Lviv Polytechnic National University,
Institute of Computer Science and Information Technologies, CAD Department,
Warsaw University of Technology,
Institute of Telecommunication, Poland
AGH University of Science and Technology, Poland
Supported by IEEE MTT/ED/AP/CPMT/SSC West Ukraine Chapter
and Lviv Regional State Administration
with Technical Co-Sponsorship of the IEEE Electron Devices Society

П279 2013 Proceedings of IXth International Conference on Perspective Technologies and Methods in MEMS Design. – Lviv: Lviv Polytechnic Publishing House, 2013 – 202 p.
ISBN 978-617-607-424-3

This book contains proceedings of the conference, devoted to problems in the field of microelectronics embedded (built-in) systems and computer equipment.
The publication is intended for scientists, postgraduates and students

ББК 32.965.3

Responsible for issue Melnyk M.R.
Materials are in author's edition

ISBN 978-617-607-424-3

ББК 32.965.3
П279
УДК 681.52

Організатори конференції:

Національний університет „Львівська політехніка", Україна

Варшавська політехніка, Інститут телекомунікацій, Польща

Гірничо-металургійна академія імені Станіслава Сташиця, Польща

За підтримки Західноукраїнського об'єднаного осередку IEEE

та Львівської обласної державної адміністрації

П279 ПЕРСПЕКТИВНІ ТЕХНОЛОГІЇ І МЕТОДИ ПРОЕКТУВАННЯ МЕМС : Матеріали IX Міжнародної конференції MEMSTECH 2013. – Львів: Видавництво Львівської політехніки, 2013 –202 с.
ISBN 978-617-607-424-3

У книзі зібрано матеріали конференції, присвяченої проблемам у галузі мікроелектроніки, вбудованих систем та комп'ютерної техніки.
Видання призначене для науковців, аспірантів та студентів старших курсів

ББК 32.965.3

Відповідальний за випуск – к.т.н., Мельник М.Р.
Матеріали подано в авторській редакції

ISBN 978-617-607-424-3

Contents

Decision Support System for Software Architect

Alexandr Harchenko[1], Ihor Bodnarchuk[2], Iryna Halay[1]

[1] National Aviation University, Kosmonavta Komarova ave. 1, Kyiv, 03058, UKRAINE, E-mail: harchenko_a1@voliacable.com

[2] Ternopil Ivan Pul'uj National Technical University, Ruska str., 56, Ternopil, UKRAINE, E-mail: bodnarchuk.io@gmail.com

Abstract — Represented system is for supplying of architect with data, knowledge and methods needed to make decisions in the process of software systems (SS) design. It includes two subsystems: first one is subsystem of requirements specification and communication to SS, and second is architecture design subsystem. For requirements specification and communication formalism of basic protocols method and technic of expert pairwise comparisons are used. The selection of architecture decisions is represented as model of multi criteria hierarchic optimization, where modified Analytic Hierarchic Process (AHP) was applied. Main units of the system is implemented as formalized models or software units.

Key words **— decision support system; software system architecture, optimization, requirements to the software system.**

I. INTRODUCTION

Development of modern software products requires from designers to take to account significant amount of data, knowledge, factors to make effective decisions. Software systems are highly intellectual products, what complicates the process formalization of their design, and this, in own turn, does not allow to develop and use automation tools for these processes. Thus applying of formal methods like mathematical modelling, optimization, decision support theory to producing of models of design processes and creation on their basic the automation tools for decision support is actual at present.

Especially it is important on the stage of requirements specification and architecture design because these stages are the first and correction of wrong decisions made here leads to great losses. Nowadays automation systems have being using for design of requirements but it concerns to functional requirements only [1]. Talking about quality requirements some obstacles appear both during design process formalization and during requirements communication.

In [2] to solve these problems the SQFD method (Software Quality Function Deployment) was used. In the proposed system these problems were solved with applying of formalism of basic protocols method [3] and expert method of pairwise comparisons matrices.

Two standard approaches for design of software architecture are used. First one consist in characteristics evaluation of selected sample of architecture with simulation method [4].

In the methods of other approach architecture characteristics are evaluated on the basic of expert questioning results. For example, in the ATAM method (Architecture Trade-Off Analysis Method) the risks that architecture does not meet conceptual requirements are evaluated [5]. The conceptual requirement of one stakeholder in the ATAM method is described with scenarios. Then alternatives are examined on the subject. Then the alternatives are analyzed in subject of supporting each of the scenarios. The disadvantages of both approaches is the limited number of aspects of software system use, that can be simulated together, and not sufficient formalization and high costs.

In represented system quality architecture evaluation is performed as solving of multi criteria hierarchic optimization problem [6]. Alternative architectures are compound with patterns that are stored in the repository as frames.

Modified algorithm of weight indices calculation is used what allowed to expand the limits of method appliance for the cases of big quantity of alternatives ($n > 9$).

II. THE SYSTEM STRUCTURE AND FUNCTIONALITY

The general look of the system is represented in the Fig. 1.

The system consists of data warehouse, where architectural patterns are stored, and program units which provide data input and their logical processing (OLTP), and units that perform informative processing – Data Mining.

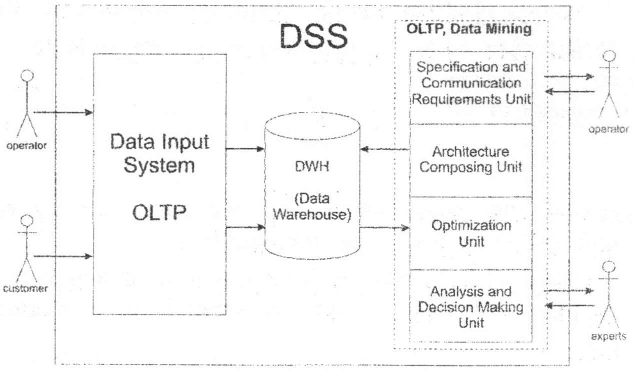

Fig. 1. System structure

A. Unit of requirements cpecification and communication.

This unit is a modification of software complex represented in [2]. But unlike of that one here for formalized representation of requirements and for the process of their communication the formalism of basic protocols method is used [3]. Specification of requirements is an aggregate of properties that behavior of the software system must satisfy. These properties may be represented using the formalism of basic protocols.

Basic protocol is an expression like $\forall x(\alpha\langle u\rangle\beta)$, where x is a list of typed parameters, α and β – formulas of basic language, u – a process of the protocol. Formula α is a precondition and formula β is a postcondition of basic protocol. The basic protocol is treated as a formula of temporal logic that express the fact when (for certain values of parameters) the state of the system has a markup what satisfy the condition α, so the process u transfers the system to the state what meets the demands of condition β. Basic protocols formalize requirements to the software system. Postcondition express the state of the system after the execution of basic protocol. To write down α and β language closed to the language of specification is used. For definition of processes the language of algebra of processes is used like CCS, CSP or languages like UML, MCS or SQL. In [3] this formalism was used successfully for requirements verification to telecommunication systems.

In our case precondition α are requirements of quality of software system, specified in terms of standard ISO/IEC 25010 and postcondition β is requirements of quality of software system architecture. The process u is a process of communication (transformation) of α into β that is realized by means of expert technic of pairwise comparisons. Its sense consists in composing of matrix $B^s\left(b_{ij}^s\right)$, where b_{ij}^s expresses how the influence of i^{th} criteria of architecture quality exceeds the influence of i^{th} criteria on the realization of s^{th} criteria of software product quality. From built matrix the weight indices $w_i^s\left(i=\overline{1,n}\right)$ of architecture quality are calculated. Assigning priorities for the quality criteria of software system $P_s\left(s=\overline{1,m}\right)$ we calculate integral weight indices

$$\overline{w_i} = \sum_{s=1}^{m} w_i^s \cdot P_s . \qquad (1)$$

And with constraint $\overline{w_i} \le \overline{w_t}$ we obtain criteria of architecture quality that are included in β.

Using of basic protocols formalism allowed to unify the notation of α and β and to simplify programming process.

B. Architectures optimisation unit.

The structure chart of selection of architecture decision with taking to accounting of indices of quality is depicted on the Fig. 2.

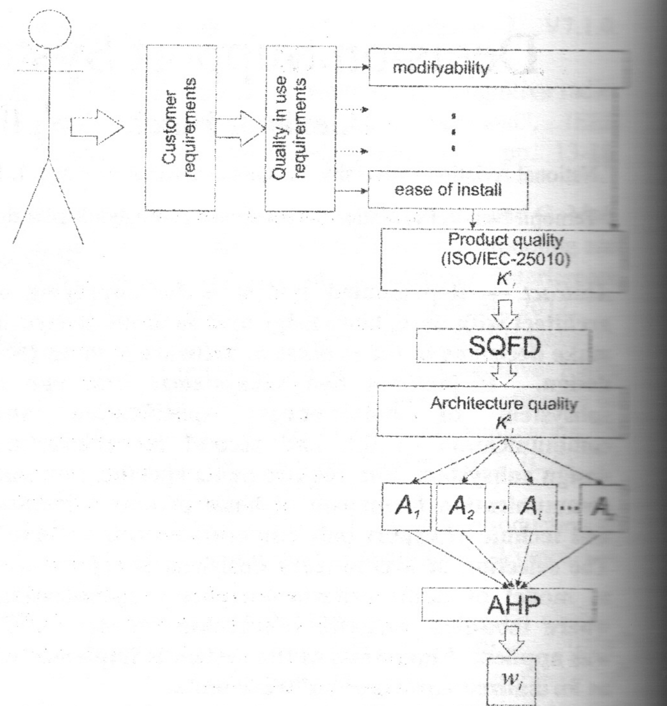

Fig. 2. Hierarchic representation of the Architecture optimization problem.

$K_i^1, i=\overline{1,m1}$ – criteria of quality of software system according to the standard ISO/IEC 25010;

$K_i^2, i=\overline{1,m2}$ – criteria of architecture quality;

$A_i, i=\overline{1,n}$ – alternative architecture decisions.

The list of quality in use criteria is defined by software system developer together with customer and architecture quality indices $\{K_i^2\}$ can be defined by means of communication of criteria $\{K_i^1\}$ on the base of QFD method with accounting of recommendations of standard ISO/IEC 25010.

It is needed to select such architecture decision what should optimize the aggregate of criteria $\{K_i^1\}$, $\{K_i^2\}$. This is the problem of multicriteria hierarchical optimization and for the solution of such problems the Saaty's analytical hierarchic process (AHP) is used most often [7].

When AHP is used to solve such problems the weight indices w_i of alternatives (criteria) on each level are calculated by means of matrices of pairwise comparisons which are filled up by experts (here b_{ij} defines the supremacy of i^{th} criteria over j^{th}).

Indices of matrix must be consistent i.e. $b_{ij} = w_i / w_j \ \ \forall b_{ij} \in B$. Weight indices in this case are calculated as eigenvector of matrix of pairwise comparisons which correspond to maximum characteristic number of matrix. But for considerable number of alternatives since influence on the experts of different factors the matrix $B(b_{ij})$ is inconsistent and its rank will differ from one i.e. the matrix will have some eigenvalues. So why in [6] for solution of problems of optimal hierarchic decisions making on inconsistent matrices of pairwise comparisons it is proposed to find the weight indices of alternatives on the base of condition of minimization of inconsistency for matrix $B(b_{ij})$.

For possibility to choose the level of consistency when calculating we introduce the threshold value of consistency δ_t and measure of consistency we will write down as follows

$$\left|\frac{w_i}{w_j} - b_{ij}\right| \le \delta_t \cdot b_{ij}, \quad \delta_t \ge 0, \tag{2}$$

where δ_t is given threshold value.

Then weight indices w_i which minimize (2) we can find as solution of following problem

$$\min_{\{w_i\}} \sum_{i=1}^{n}\sum_{j=1}^{n}\left(w_i - b_{ij}w_j\right)^2 \tag{3}$$

$$a_i \le w_i \le c_i, \quad i = \overline{1,n}$$

$$-\delta_t \cdot b_{ij} \cdot w_j \le w_i - b_{ij} \cdot w_j \le \delta_t \cdot b_{ij} \cdot w_j; i,j = \overline{1,n}. \tag{4}$$

The problem (3), (4) is nonlinear programming problem and through the change of variables it can be brought to the equivalent linear programming problem:

$$\min_{\{w_i\}} \sum_{i=1}^{n}\sum_{j=1}^{n}\left(y_{ij}^{+} - y_{ij}^{-}\right)$$

$$w_i \ge a_i\, i = \overline{1,n}, \tag{5}$$

$$w_i - b_{ij}w_j = y_{ij}^{+} - y_{ij}^{-}.$$

$$-\delta_t \cdot b_{ij} \cdot w_j \le w_i - b_{ij} \cdot w_j \le \delta_t \cdot b_{ij} \cdot w_j,$$

$$y_{ij}^{+}, y_{ij}^{-} \ge 0; i,j = \overline{1,n}. \tag{6}$$

The equivalence of problems (3), (4) and (5), (6) follows from the fact that vector of constraints at y_{ij}^{+} and y_{ij}^{-} are linearly dependent and therefor any solution belongs to y_{ij}^{+} or in y_{ij}^{+} and therefor the minimum (5) corresponds to the minimum (3). For each criterion the matrix $B(b_{ij}^{s})$ is composed, where b_{ij}^{s} shows how i^{th} alternative exceeds j^{th} in the realization of s^{th} criterion. For obtained matrices the sets of weight indices w_i^s, $i = \overline{1,s}$, $s = \overline{1,7}$ are defined as solution of the problem (5), (6). For ranging of alternatives on the set of criteria it is needed to find their priorities. To define the priorities of quality indices of architecture $\{K_i^2\}$ for their influence on the realization of quality indices of software system $\{K_i^1\}$ experts fill up the matrix of pairwise comparison $B^s(b_{ij}^{s})$, where the value b_{ij}^{s} defines how the influence of criterion K_i^2 exceed the influence of criterion K_j^2 on the realization of quality criterion K_s^1 of software system. Applying modified AHP we will obtain the sets of priorities of criteria of architecture quality $\{P_i^{1s}\}$, $i = \overline{1,m2}$, $s = \overline{1,m1}$. Then the weight of alternate architecture A_i regarding the realization of criterion of software system quality K_s^1 will be calculated according to the formula:

$$J_i^{1s} = \sum_{j=1}^{m2} p_j^{1s} \cdot w_i^j, \quad i = \overline{1,n}, \quad s = \overline{1,m1}, \tag{7}$$

w_i^j – are weight indices defined on the previous stage.

Now we can range the alternatives $\{A_i\}$ according to the value $\{J_i^s\}$ for each $s = \overline{1,m1}$, i.e. the sets of alternatives will be got $\{A_i^s, P_i^{1s}\}$, $s = \overline{1,m1}$.

C. Analisys and decision making unit

To make final decision for the selection of the alternative architecture, the results outgoing from the optimization unit are performed.

Since some groups of specialists take part in the process of software system development with different priorities for each quality attribute so the priorities for every group are defined by forming of matrices of pairwise comparisons, and using AHP the priorities of criteria $\{P_i^s\}$, $i = \overline{1,k2}$ are found, where s is a number of group of experts. Compromise decision is made as geometric mean $P_{ij}^{*} = \sqrt[n]{P_{ij}^{1} \cdot P_{ij}^{2} \cdot \ldots \cdot P_{ij}^{n}}$ or as weighted averaged with taking to account the index of competency for experts group $P_{ij}^{*} = P_{ij}^{\alpha_1} \cdot P_{ij}^{\alpha_2} \cdot \ldots \cdot P_{ij}^{\alpha_n}$, ($\alpha_1, \alpha_2, \ldots, \alpha_n$ are indices of competency).

To achieve compromise during making the final decision and as well when the requirements to the software system is changed during its development the priorities of quality attributes may be changed. In this case for correcting of criteria priorities the expression is used

$$D'_{s,i,j} = \frac{\left|J_i - J_j\right|}{\left|w_i^s - w_j^s\right|} \cdot \frac{100}{P_s}. \tag{8}$$

Here $D'_{s,i,j}\left(s = \overline{1,m2}; i,j = \overline{1,n}; i \ne j\right)$ is minimal change of the priority P_k for the criterion of quality K_s that changes the order of adjacent architecture alternatives A_i and A_j on reverse. The minimal value of $D'_{s,i,j}$ shows that the priority P_s of the attribute K_s is critical for the changes of opinions in pairwise comparisons.

Using Eq. (8) for each criterion K_s we are available to find the interval ΔP_s in which experts can correct priorities P_s directly or by changing of values of pairwise comparisons without changing of order of the ranged alternatives $D_s^* = \min_i D_{s,i,j} = \Delta P_s$, $i = \overline{1,n}$, $s = \overline{1,k_2}$.

If we need to range alternatives regarding to the global quality of software system, it is necessary to find the priorities of quality criteria fo software system $\{P_i^2\}$, $i = \overline{1,m1}$ with applying of modified AHP.

The weights of alternatives regarding the realization of global criterion of quality for software system can be found with following index:

$$J_i^0 = \sum_{s=1}^{m1} J_i^{1s} \cdot P_s^2, \quad i = \overline{1,n}. \tag{9}$$

Then the index of importance of the alternative A_i on the set of criteria will be

$$J_i = \sum_{j=1}^{m2} P_j \cdot w_j^i, \quad i = \overline{1,n}, \tag{10}$$

and $\{A_i\}$ will be ranged according to the values $\{J_i\}$.

Obtained ranged alternatives regarding to both individual indices and to their totality on the level of quality of software system are used to making the final decision for architecture selection.

III. Conclusion

Using of proposed system during the software design Using of the proposed system in the software design will allow for the use of formal models, repository, ready-made architectural patterns, and optimization techniques to improve the quality of software products, reduce development time and decrease costs.

Applying of the method of communication for quality requirements will allow reasonably to select quality criteria of the architecture, and using of the algorithm of defining of weight indices for the architectures in the AHP extends margins of method applying for lager quantity of alternatives ($n > 9$). The technic of architecture composing and using of patterns repository gives possibility to use affectively ready-made architectural patterns during selection of optimal decision for the wide range of software categories (applications).

References

[1] Hull E. Requirements Engineering. Second edition / Elizabeth Hull, Ken Jackson, Jeremy Dick. // Springer Science+Business Media, 2005.–198 p.

[2] Harchenko A., Yatcyshyn V., Raichev I"A tool of quality requirements development and communication for software systems," in*Software Engineering*, vol. 2, 2010, pp. 29-34. (Харченко О. Інструментальний засіб розробки та комунікації вимог якості до програмних систем/ О.Г.Харченко, В.В.Яцишин, І.Е.Райчев // Інженерія програмного забезпечення.-2010.-№2-С.29-34.)

[3] Letichevsky A. Basic Protocols, Message Sequence Charts, and the Verification of Requerements Specifications. / A. Letichevsky, J. Kapitonova, A. Letichevsky Jr., V. Volkov, S. Baranov, V. Kotlyarov//ISSRE 2004, WITUL, Rennes, 4 November 2005.– p. 112 – 142.

[4] Clements P. Evaluating Software Architectures: Methods and Case Studies. / Kazman R., Klein M. Boston: Addison Wesley, 2002. – 323 p.

[5] Bass L. Software architecture in practice / Len Bass, Paul Clements, Rick Kazman – 2nd ed.Boston, MA: Addison-Wesley Professional, 2003.– 528 p.

[6] Harchenko A. Software Architecture Design on the Base of Method of Hierarchic Optimization. / Harchenko A., Bodnarchuk I., Halay I., Yatcyshyn V. // Proceeding of the VIII International conference on MEMS Design. Lviv – Polyana. 2012. –pp. 39 – 40.

[7] Saaty T. Decision Making with the Analytic Network Process Saaty T.,Vargas L.– N.Y.: Springer, 2006. – 278 p.

Наукове видання

ПЕРСПЕКТИВНІ ТЕХНОЛОГІЇ І МЕТОДИ ПРОЕКТУВАННЯ МЕМС

Матеріали IX Міжнародної конференції MEMSTECH 2013

Відповідальний за випуск – к.т.н., Мельник М.Р.

Підписано до друку 8.04.2013
Формат 60×84 1/16. Папір офсетний. Друк на різографі.
Умовн. друк. арк. 23,2. Обл.-вид. арк. 14,3.
Наклад 300 прим. Зам. 130404

Видавець: Видавництво Львівської політехніки
Свідоцтво суб'єкта видавничої справи ДК № 4459 від 27.12.2012 р.

вул. Ф. Колесси, 2, Львів, 79000
тел. +380 32 2582147, факс +380 32 2582136
vlp.com.ua, ел. пошта:vmr@ vlp.com.ua

Виготівник: ПП „ВЕЖА і Ко"
м.Львів, вул. Бескидська, 37, 79059