

POKUS O VALIDACI VNITŘNÍCH A VNĚJŠÍCH MĚR ISO/IEC PRO JAKOST SOFTWARE

THE ATTEMPT FOR THE ISO/IEC SOFTWARE QUALITY MEASURES VALIDATION

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Anotace:

Příspěvek shrnuje výsledky průzkumu provedeného na Provozně ekonomické fakultě České zemědělské univerzity v Praze o užití vnitřních a vnějších měr (metrik) jakosti softwaru. Průzkum byl snahou validovat míry (metriky) navržené v technických zprávách ISO/IEC 9126-2 a 9126-3 tak, aby vybrané míry bylo možné včlenit do mezinárodních norem. Průzkum ukázal vážné nedostatky a výhrady uživatelů k těmto mírám a na nutnost hluboké revize množiny měr před rozhodnutím které míry převzít do soustavy norem ISO/IEC 250xx, vyvíjených v rámci mezinárodního výzkumného projektu SQuaRE.

Klíčová slova:

model jakosti ISO/IEC, metriky pro jakost, vnitřní míry, jakosti vnější míry jakosti, charakteristiky jakosti, validace, průzkum využívání

Abstract:

The paper heaps together the research results performed on the Faculty of economy and management Czech university of agriculture in Prague concerning the utilization of external and internal software quality measures (metrics). The pursuit of this research was the validation of measures (metrics) recommended in the ISO/IEC 9126-2 and 9126-3 technical reports with the goal to incorporate selected measures to international standards. The research presents the serious deficiencies and users provisions concerning these measures and the necessity of a deep revision of the set of measures before the decision about incorporating these measures into the ISO/IEC 250xx standards series developed within the SQuaRE international research project.

Key words:

ISO/IEC quality model, quality metrics, external measures, internal measures, quality characteristics, validation, user research

INTRODUCTION

In 1991, ISO has published the first international standard ISO/IEC 9126 “Software Product Evaluation – Quality Characteristics and Guidelines for their use [1]. In 2001, ISO made revision and enhancement on the ISO/IEC 9126 standard and published a new series of standards. The ISO/IEC 9126:1991 has been replaced by two related multipart standards: ISO/IEC 9126 (software product quality) and ISO/IEC 14598 (Software product evaluation)

The first IS, ISO/IEC 9126, consist of on standard and two technical reports under the common title Information Technology – Software Product Quality [2] - [5].

ISO 9126-1: Quality model.

ISO TR 9126-2: External metrics.

ISO TR 9126-3: Internal metrics.

ISO TR 9126-4: Quality in use metrics.

The second IS consists of six standards under the common title Information Technology – Software product evaluation [6] – [10].

ISO/IEC 14598-1: General overview.

ISO/IEC 14598-2: Planning and management.

ISO/IEC 14598-3: Process for developers.

ISO/IEC 14598-4: Process for acquirers.

ISO/IEC 14598-5: Process for Evaluator.

ISO/IEC 14598-6: Documentation of evaluation modules.

From the authors point of view the main weakness of these sets of standards is the lame selection of attributes and their metrics, in the new terminology accordance with ISO/IEC 15939 Information technology – Software measurement process [11] measures in ISO/IEC 9126 -2, -3 and -4. The sets of attributes and measures nominated in these technical reports are too extensive, not consistent and contain also bad defined measures.

The ISO/IEC JTC1 committee for Information technology has recognized a need for further enhancement of standards for software product quality primarily a result of advances in the fields of information technologies and changes in environment. Therefore, the ISO is now working on the next generation of software product quality standards [12] and [13], which will be referred to as Software Product Quality Requirements and Evaluation (SQuaRE – ISO/IEC 25000). This series of standards will replace the current the current ISO/IEC 9126 and ISO/IEC 14598 series of standards. The SQuaRE series will consist of five divisions:

Quality management division (ISO/IEC 2500n).

Quality model division (ISO/IEC 2501n).

Quality measurement division (ISO/IEC 2502n)

Quality requirements division (ISO/IEC 2503n).

Quality evaluation division (ISO/IEC 2504n).

This work is being carried out by the working group 6 (WG6) of the Software and System engineering sub-committee (SC7). One of the main objectives of (and difference between) the SQuaRE series of standards and the current ISO/IEC 9126 series of standards is the coordination and harmonization of its contents with ISO/IEC 15939 and the care for a consistency between the individual standards of the new 250xx series.

The author of this contribution expects that in the preparation of the SQuaRE standards one problem is still underrated and not solved by the responsive effort. This problem is the selection of an agreed not unduly extensive set of attributes and measures that cover all quality characteristics and subcharacteristics. This problem is of course arduous due to different experiences and practices in various countries and different concerns of various software producers and acquires. Nevertheless author is convinced that the selection of an appropriate set of attributes and measures are a necessary condition for the success of the SQuaRE project.

OBJECTIVES AND METHODOLOGY

In this situation, within the research project MSM6046070904 Information and knowledge support of strategic decision process the research with the target to map, which attributes and measures are used by software developers, acquires and evaluators in the practices and to map the experiences with ISO/IEC 9126 usage have been done. On the Department of information engineering, Faculty of economy and management the research was realized on the period 2002 - 2006. One full professor, 6 doctoral students and 12 master degree student take a part in large scale inquire research, which cover 10 software developers, 12 system integrators and 48 information systems users in Czech Republic. Developers, system integrators and users companies were of very different size, from the branches of the

main worldwide software companies to the small software houses with the staff from 10 to 20. The methodology of investigation was different for various respondents. From of formal questioners fulfilling to informal talk with staff.

RESULTS

General perception from the research is that about 80% of software developers and system integrators declare the systematic care for software and system quality. Though they are more concentrated to the process control than to the product control. The ISO 9000 series standard are known and used. Only about 50% of these companies are familiar with ISO/IEC 9126 and ISO/IEC 14598 standards and use some measures recommended in these technical report. Nobody follows consistently the process according to ISO/IEC 14598 and evaluate all quality characteristics defined in ISO/IEC 14598 by internal and external measures recommended in related technical reports. But about 60% of these companies follow some quality prediction methods and quality testing which are similar with ISO/IEC 9126 quality model and use some measures, which can be found in respective technical reports or are some modification of the measures listed in these reports.

Contacted acquires and end users prefer for its decision of the information system or software product provision or in competitive tendering the references about the vendors reputation before the proper systematic quality audit of the offered product. Still each user has declared some quality evaluation. This evaluation is in about 50% of cases concentrate to functionality evaluation only. Only about 20% of acquires evaluate in fact all six or at least 5 selected five quality characteristics from ISO/IEC 9126. Mostly they have no information about ISO/IEC 9126 quality model, but follow some own methodology with is similar.

Concerning the measures used in practices is the following. Plenty of measures recommended in 9126 -2, -3 and -4 has the form A/B , where B is number of some properties of the evaluated entity, which are satisfied and B is the number of properties required. The range of such a measure is always a close interval $<0, 1>$ and the rating “the closer to 1 is the better”. Such a “normalization” of measures allows comparing the measures for different attributes. However it is only seldom indigent in the practices. More needful is the comparison of requirements different required measures of various users and various stakeholders for the same attribute of the product in question. Second need is often to compute the measure value for some attribute of a complex entity by the reconciliation of measures acquired for its elements. The “measures” of the A/B type don’t allow doing it. In fact such a fractions are not quality measures for the given entity, but the result of comparison the actual measures with measure indicators derived from individual quality requirements for concrete user or stakeholder. This comparison is not a part of measure process. This step is important, but shall be realized later, after the measurement. It is the part of measurement evaluation stage (see ISO/IEC 16939 - [11]) and can lead to different results for different stakeholders. This fact and the opportunity to concatenate the measures obtained for installments of a complex product is the reason, why the fraction measures are not used and evaluators prefer to enroll the nominator A only as a proper measure of the entity.

The critical appreciation of users for concrete software quality measures in ISO/IEC 9126 -2 and -3 come next. The measures for quality in use were not reported in the query. The thing is that these measures are not a product measures but the process measures for the quality of information pressing in the users company. Such information is customarily judged as confidential and companies are not obliging to communicate it.

Functionality is on the top of the respondent’s concernment. All respondents that realized some quality evaluation have the functionality evaluation as a part of the evaluation process.

Suitability subcharacteristic is for functionality judged as an underlying by all respondents. It is often measures by the variant of “functional implementation completeness” and/or “functional implementation coverage” attribute and corresponding external or internal measure. The difference between these two attributes and measures is little bit fuzzy. First counts all functions, which are “present”. The second counts only functions, which are “complete”. Source of the problem consists in the absence of correct and lucid definition of the term “number of functions”, which is important quality measure element. Functions form not a linear structure, but the multilevel hierarchy. One complex function can be considered as a collection of some elementary or less complex functions. One upper level function which is realized, but its realization is not complete can be considered on the lower level in this hierarchy as a set of functions in which some functions are realized and some not. The second problem is, that not all functionality requirements of users and stakeholders have the same importunity. Some functions are absolutely necessary, some have the grate priority, some can be cozy, but not necessary and some have only a minimal importance. Therefore the suitability is often measures by the weighted functional coverage or using the multilevel functional coverage.

In weighted functional coverage the natural number w_j , so called weight, from some scale is assigned to all elementary function (function on the lowest level of hierarchy of functions). If we have N function in this level and for each $j = 1, \dots, N$ we put $s_j = 1$ if the function is realized and $s_j = 0$ if not, then the coverage can be compute as $\sum_{j=1}^N w_j \cdot s_j$. The disadvantage of this measure is, that is exists a great number of offered functions with the lower importance, it is the danger that many small benefits can outbalance the serious disability. The world and life is however not always Archimedean and therefore this measure can be sometime also problematic.

In multilevel coverage we shall split all function to M (usually from two to five) levels of the importance. In each level we compute the weighted or not weighted functional coverage. The result is the generalized measure, which is a M -part vector (c_1, c_2, \dots, c_M) . For each component of this vector the required value of the quality indicator have to be adjusted separately. Ordinarily for c_1 the maximum value is required. As a rule it is not ordered any required measure value for the lowest level coverage c_M . If we construct the order according this attribute, we compare first the first members of the vectors, if it is equal, then second, if also the second coordinates are equal the third and so on. Let us mentioned that according the well known Birkhoff and Milgram theorem this vector measure can be replaced by the traditional one number measure of the ordinal scale type.

Respondents addressed in the research have good experiences with the multilevel or weighted coverage as a suitability attribute and measure. The same multilevel or weighted principle is often used also for the modification of other measures recommended in respective ISO/IEC technical reports.

Accuracy was not the topic of evaluation of the respondents, except of one case, the programs for meteorological forecasts. In this case the stability of matrices inversion algorithm for large matrixes are the subject of interest. For this special problem the much more sophisticated measures, than measures recommended in 9126-2 was used.

Interoperability is the subject of interest of many users. The situation is similar that in the case of suitability measures. The data format based consideration is performed more rife than the user success attempt consideration. For evaluation the weighted or multilevel evaluation is used.

Security is important issue for many users. However nobody uses for the evaluation of the security the ISO/IEC quality model and measures recommended in technical reports ISO/IEC 9126 -2 and -3. Users prefer to use special security standards; in the first place the Common criteria standard.

Compliance in functionality is out of interest of users in question. The same situation occurs in the compliance subcharacteristics of all other quality characteristics.

Reliability is after functionality the second most interesting quality characteristic for the respondents.

Maturity is evaluated by about 50% of respondents. The multilevel variants of the attributes “failure density”, “failure resolution” and “mean time between failures” are mostly used. The failures are classified usually into three levels.

The crash - when the failure cause to serious damage, for example to loss of important data,

the break-down - when the functionality is completely refused and the user task is suspended, but without serious additional damages and

the cutback - when the functionality is preserved, but on the limited restricted level of performance. The measures based on the potential number of failures, predicted using a reliability growth estimation model, such as “estimated latent failure density” or “estimated latent fault density” not used by respondents.

Failure or fault density measures, which divide the number of failures or faults by the product size, are used by about 50% of software developers, but mostly not for the evaluation of product quality, but yet for the valuation of developers process and staff rating. Of course the problem is in the definition of the term “program size”. The assessment of the size by number of lines of source code (so called measure LOC) seems to be applicable only with great problems, because the complexity of the problem, programming languages or CASE tool used and developer’s environment can be for the size more important then the physical length of the code.

Majority of software developers use the measures “test coverage” and „test overcome“ in various stages of the product life cycle. In case of test coverage measure the problem is to distinguish detached scenarios for which the individual test is required.

Fault tolerance usually is not evaluated by any special attributes and its measures, such as “failure avoidance” and “incorrect operation avoidance” is investigated. The reaction of the system to incorrect data input or/and invalid operation during the program execution is assessed as a part of system functionality. Operation with error input is considered as a part of functionality requirements. Different risk levels that denounce from the software fault evoked failure are diversified by the classification of failures to appropriate levels (usually as crash, break-down and cut-back).

Recoverability is sometimes evaluated by the attribute “availability”, defined as a ratio $T_o/(T_o+T_r)$, where T_o is an operation time of the system and T_r the time consumed to repair it, is recorded by many users and considered as a major reliability indicator. For the “down time” attribute the maximum down time variant is considered as more interesting as the mean down time variant. The same is true for the restart time. The pessimistic estimation is considered as a more important attribute.

Usability is rarely assessed and evaluated using the objective measurement process.

Understandability of the product and its attributes like “completeness of description” and “demonstration availability” and “function understandability” is sometime estimated indirectly during the functional implementation coverage measurement.

Learnability is measures only using the time required to learn the function and operation to perform the task. If the system is able to perform an extensive set of functions, obviously two values are interesting for users. The time necessary spending to perform the base set of all-important functions and the time necessary spending to perform all special functions and take the advantage from the utilizing all advanced systems features. Some users also estimate

the help system, but in majority only using a subjective estimation in the ordinal scale measure scale type estimation.

Operability is evaluated on the similar way as learnability above. The discrepant measures proposed on ISO/IEC 9126 -2 and -3 are not used. The features like automatic error input correction and/or default value availability are mostly considered as problematic and dangerous in regard of the reliability of the system. The user operation time is measured by the actual time needed to perform the task. For reiterative tasks the pessimistic estimation of the maximum is considered as a more interesting attribute then the mean or average time.

For the *attractiveness* respondents sometimes use only subjective ordinal scale type estimation.

Efficiency is mostly out of the interest of developers and users inquired.

Time behavior was interesting for the Internet web products with potentially many parallel users, working in the same time. For such product providers the “response time” is considered as a key parameter of the system. In the case of the anticipation of loading for such a system is disproportionate, the pessimistic worst case “maximal response time” is considered as a more interesting measure then the mean response time. However the objection of measure users is that the response time problem cannot be adequately described using one number only. More adequate is to measure this time by a function which free variable is the number of on line users and the value the response time.

The turnaround time was used as efficiency attribute only by two users, working with the special software realize the sophisticated mathematical algorithms to solve extensive systems of difference equations.

Any our respondent does not apply *resource utilization* measures recommended in ISO/IEC 9126 -2 and -3.

Maintainability is considered as an important quality characteristic by developers and also by users. However only few developers use the internal measures recommended in ISO/IEC 9126 -3. The reason probably is, that for the developer’s process softwarehouses use various integral methodologies that contain its own inbuilt tools for the maintainability control. These tools are concentrated to the documentation of the project and the document flow during the stages of the project life cycle. Therefore we have to concentrate to the external measures applied mostly by software users and system integrators.

Analyzability is measures only by few respondents. The attribute “failure analysis time” is used, still not as a fraction, but as a time at which the causes of failure are found out, only. The same variant of the proposed measure is between whiles used for the “diagnostic support” attribute.

Changeability is measured by some respondents, using the time spent to implement changes in the new version or modification of the software. This measure is a variant of some measures recommended in ISO/IEC 9126 - 2.

Some respondents evaluate *stability* by recording the failure frequency in consequent versions or modifications of software and computing the ratio of these frequencies. It is conform to the attribute “less encountering failures after change”, defined in ISO/IEC 9126-2. Some users prefer for the stability evaluation the attribute main time between two consecutive version unfreezing and deliveries. For such users there exists some optimal time, which is considered to be the best. Very frequent version changes are considered as annoyance. The large interval between versions is considered as incompetence to repair faults in software.

Some respondents evaluate *testability*, still not according the measures recommending in ISO/IEC 9126 –2, but only recording simple the time spending by the test run after the implementation of the new version of software.

Portability is evaluated by developers only in two projects. This evaluation was limited to the problem of application software design that works on the Microsoft windows and Unix-like operation systems environment.

Adaptability is evaluated by any respondent. No users try to adapt software to different environment oneself.

Installability is considered by respondents usually as a part of functionality or efficiency. The measures recommending in ISO/IEC 9126 –2 are not used.

Replaceability some users evaluate using the time necessary spending for data migration to the new environment and the user effort spending to the adaptation of the software environment. The measures recommended in ISO/IEC 9126 –2 was not used.

Co-existence is also considered by respondents as a part of functionality subcharacteristic interoperability, or as a part of reliability characteristic. The measure “concurrent multiple software use with less constrains”, recommended in ISO/IEC 9126 -2 is based in fact on the number of failures.

DISCUSSION

The research demonstrates, that the level of software product quality using in Czech republic is relatively low, comparable with advanced countries. The information technology market is more the market of supplier, then the market of purchaser. Therefore the standards for developing process are more popular comparable with standards for product evaluation from the users point of view.

There are not enough experiences with product quality standards. Quality is often regarding only as functionality. Acquires are only seldom able to formulate the exact requirements with qualify their real needs. Acquires often make his decision concerning the product choice using different criteria then the product quality.

The quality attributes and measures recommended in ISO technical report represents an extensive and blind set and it is not easy to realize a feasible choice of attributes in concrete situation.

CONCLUSION

The described research shall be completed by the research in other countries, with different experience in information technology market and different vendor – buyer culture and result s shall be summarized. As the author knows, the similar research is realized in Korea. After that, the recommendation for a relative small and lucid set of recommended software product quality attributes shall be given. The selected attributes and measures, probably in two levels as based and optional, shall be integrated into now building up SQuaRE ISO/IEC 250xx series of standards. Without the responsible choice of attributes and measures the SQuaRE project cannot be resultful and other branches of the ISO/IEC 250xx series can be only a scholastic unhelpful and void ideas.

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