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Software Quality Assessment for Health Care Systems

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Abstract. The problem of defining a quality model to be used in the evaluation of the software components of a Health Care System (HCS) is addressed. The model, based on the ISO/IEC 9126 standard, has been interpreted to fit the requirements of some classes of applications representative of Health Care Systems, on the basis of the experience gained both in the field of medical Informatics and assessment of software products. The values resulting from weighing the quality characteristics according to their criticality outline a set of quality profiles that can be used both for evaluation and certification.

1. Quality Models

Software products need to be evaluated to decide whether relevant quality characteristics meet the requirements of the system according to the objectives of the system itself. To evaluate the quality of a software product, a quality model is needed, together with a method of evaluation and a quantitative scale for measures [1].

A *model* is an abstract representation of an object: according to this definition, which is a very general one and implies the existence of several classes of models, we may conceive a *quality model* as a structured set of quality requirements.

Several high-level approaches to modelling the quality of software products have been proposed [2], [3], [4]: these models are based on the idea that there are a number of important high-level quality factors of software products which we would like to measure. These factors are determined by lower-level elements which are supposed to be much easier to measure through the presence of specific indicators, for which metrics are proposed.

As a consequence, all the proposed approaches are based on the decomposition of a set of quality attributes, to define a hierarchic structure of characteristics and a way to relate them to some technical aspects of the product. These and other efforts have led to the definition of a number of draft standards which directly address software measurement issues. The main and most popular one, the ISO/IEC 9126, gives standard definitions of quality attributes and proposed measures, together with a set of application guidelines [5].

1.1. The ISO/IEC 9126 Quality Model

This model describes software quality as a function of six characteristics:

- *Functionality*: concerning the set of functions provided by the software, together with their properties.

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- *Reliability*: concerning the capability of software to maintain its level of performance under stated conditions.
- *Efficiency*: concerning the relationship between the level of performance and the amount of resources used.
- *Usability*: concerning the effort needed by a sample set of users to use the software.
- *Portability*: concerning the ability of software to be transferred to different environments.
- *Maintainability*: concerning the effort needed to make modifications.

This decomposition reflects the users' view and introduces the idea of "quality in use": users are mainly interested in using the software product, and evaluate software mostly from the performance and the service it provides, rather than its internal aspects or development process. ISO/IEC 9126 suggests a further decomposition of each characteristic into a set of

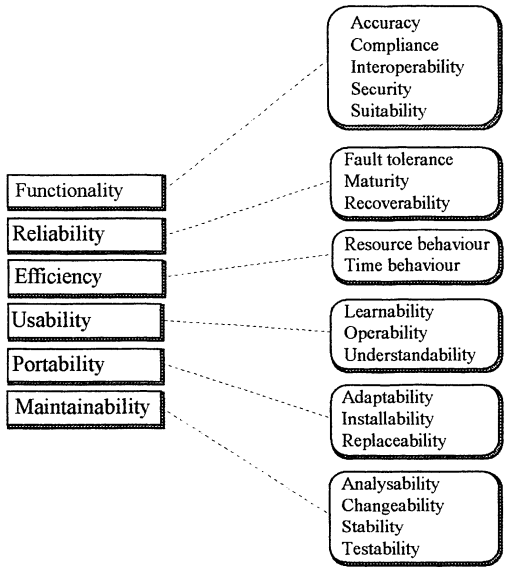

Figure 1 - Software Quality Model (ISO/IEC 9126)

sub-characteristics: these sub-characteristics are a step closer to the quantitative, technical aspects of the software product. The proposed decomposition is presented in Figure 1.

2. Quality Profiles for Health Care Systems

The quality of complex products (like software products) involves multiple aspects and cannot be expressed by a unique measure [6], [7]. Usually, quality is expressed by means of a *quality profile*, a list of measures, each one associated to a quality characteristic of the product.

Among the great variety of software products, Health Care Systems (HCS) have widely grown both in the number of technologies involved and in the functional target which they

address and can be included among critical computer systems in many respects (security, economy, safety) [8].

Because of the intrinsic complexity of a modern HCS [9], [10] it is not convenient to look for a global quality profile by applying the quality model to the whole software system. Five main categories of software components can be outlined, according to their functionality, in last generation HCS:

- *Networking*. The operating theatre calls for fast and secure integration of personal computers, workstations and special equipment for data acquisition and processing.
- *Archiving*. The success of the electronic patient record and telemedicine services depends on the existence of an archiving system able to provide fast, transparent and reliable access to data regardless of their nature (images, reports, video).
- *Scientific*. Scientific software in an HCS includes applications for pre-processing, segmentation, registration and visualisation of medical images.
- *Clinical*. A variety of medical services can be implemented on the technology platform provided by an HCS, starting from report handling up to include advanced therapeutic and diagnostic procedures.
- *Administration*. An integrated system for running a hospital organisation must provide for the economic handling of the hospital resources as well as patients.

This broad classification allows us to obtain five separate quality profiles, easier to be handled in the evaluation process.

Figures 2 to 7 show the quality profiles resulting from the application of the ISO/IEC 9126 model as a checklist to define the relevance of each sub-characteristic to each class. For each intersection (quality sub-characteristic, HCS software category) we suggest a value, representing in a five-level scale(•) the relative importance of the sub-characteristic.

	NET	ARC	SCI	CLI	ADM
SUITABILITY	M	H	VH	VH	H
ACCURACY	VL	M	VH	H	M
INTEROPERABILITY	H	H	H	M	M
COMPLIANCE	VH	VH	M	L	M
SECURITY	VH	VH	M	H	VH

Figure 2 - Functionality Quality Profile

	NET	ARC	SCI	CLI	ADM
MATURITY	VH	VH	H	H	H
FAULT TOLERANCE	VH	VH	H	H	M
RECOVERABILITY	VH	VH	H	H	VH

Figure 3 - Reliability Quality Profile

(•)

VL - Very Low
L - Low
M - Medium
H - High
VH - Very High

	NET	ARC	SCI	CLI	ADM
UNDERSTANDABILITY	VL	M	H	VH	M
LEARNABILITY	M	M	H	VH	M
OPERABILITY	H	VH	VH	VH	H

Figure 4 - Usability Quality Profile

	NET	ARC	SCI	CLI	ADM
TIME BEHAVIOUR	VH	H	VH	M	L
RESOURCE BEHAVIOUR	H	VH	VH	L	L

Figure 5 - Efficiency Quality Profile

	NET	ARC	SCI	CLI	ADM
ANALYSABILITY	M	M	M	M	M
CHANGEABILITY	H	H	H	H	H
STABILITY	H	H	H	H	H
TESTABILITY	M	M	M	M	M

Figure 6 - Maintainability Quality Profile

	NET	ARC	SCI	CLI	ADM
ADAPTABILITY	L	L	H	H	L
INSTALLABILITY	H	L	H	H	H
CONFORMANCE	H	H	M	VL	H
REPLACEABILITY	M	M	VL	VL	H

Figure 7 - Portability Quality Profile

3. Conclusions

In the "Define Your Own Quality Model" approach the Software Engineer and the User agree on which quality attributes they think are important for the product. Guided by the quality model they can agree on specific measures for the lowest level attributes (sub-characteristics).

The resulting quality profile(s) can be used:

- To assess an existing software product (as a selection criterion to choose a system matching a desired quality profile).
- as a pass-fail mechanism to be used by an independent organisation to certificate software products.
- During the development of a new product, to verify that the developer meets the specified quality targets.

4. References

[1] ISO/IEC 14598-1: Information Technology - Software product evaluation - Part 1: General Overview.
[2] Deutsch M. S., Willis R. R., "Software Quality Engineering", Randall W. Jensen, 1988.
[3] Sunazuka T., Azuma M., "Software quality assessment technology", Proceedings of the International Conference on Software Engineering (ICSE), 1985.
[4] McCall J. A., Richards P. K., Walters G. F., "Factors in Software Quality", Vol. I, II, III, US Rome Air Development Center Reports, 1977.
[5] ISO/IEC 9126-1: Information Technology - Software quality characteristics and Metrics - Part 1: Quality characteristics and subcharacteristics.

[6] Fenton N. E., "Software Metrics. A rigorous approach", Chapman & Hall, London, 1991.
[7] Bache R., Bazzana G., "Software Metrics for Product Assessment", McGraw Hill, London, 1991.
[8] Littlewood B., "The risks of software", Scientific American, 267, 5, pp. 62-75, 1992.
[9] Tsiknakis M., Chronaki C., Kostomanolakis S., Orphanoudakis S., "The Regional Health Telematic System of Crete", Proceedings of the Health Telematics '95 (Health in Information Society), Lacco Ameno Ischia, Naples, Italy, July 2-6, 1995, pp. 553-558.
[10] Nadalin C., Mainpin F., Marchiset T., "MISA: A Meta-model for Medical Information System Architecture", Proceedings of the Health Telematics '95 (Health in Information Society), Lacco Ameno Ischia, Naples, Italy, July 2-6, 1995, pp. 471-476.