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Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Measurement of system and software product quality

Ingénierie des systèmes et du logiciel — Exigences de qualité et évaluation des systèmes et du logiciel (SQuaRE) — Mesurage de la qualité du produit logiciel et du système

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 7, *Software and systems engineering*.

This first edition of ISO/IEC 25023, which is a part of the SQuaRE series of standards, cancels and replaces ISO/IEC TR 9126-2:2003 and ISO/IEC TR 9126-3:2003, with the following changes:

— the quality measures contained in ISO/IEC/TR 9126-2 and ISO/IEC/TR 9126-3 are reviewed and adopted or rejected according to the practical usefulness;

— in addition, the other quality measures are given for the revised system/software product quality model in ISO/IEC 25010;

— the internal and external measures are aggregated and represented with a simplified format in one table.

The SQuaRE series of International Standards consist of the following divisions, under the general title *Systems and software Quality Requirements and Evaluation (SQuaRE)*:

— *ISO/IEC 2500n — Quality Management Division*

— *ISO/IEC 2501n — Quality Model Division*

— *ISO/IEC 2502*n *— Quality Measurement Division*

— *ISO/IEC 2503n — Quality Requirements Division*

— *ISO/IEC 2504n — Quality Evaluation Division*

— *ISO/IEC 25050 to ISO/IEC 25099 — SQuaRE Extension Division*

Annexes A, B and C are for information only.

Introduction

This International Standard is a part of the SQuaRE series of International Standards. It provides a set of quality measures for the characteristics of system/software products that can be used for specifying requirements, measuring and evaluating the system/software product quality, in conjunction with other SQuaRE series of International Standards, especially ISO/IEC 25010, ISO/IEC 25030, ISO/IEC 25040 and ISO/IEC 25041.

The set of quality measures in this International Standard were selected based on their practical value and are categorized into two levels of reliability. They are not intended to be exhaustive and users of this International Standard are encouraged to refine them if necessary.

Quality measurement division

This International Standard is a part of the ISO/IEC 2502n series that currently consists of the following International Standards:

— ISO/IEC 25020 — **Measurement reference model and guide**: provides a reference model and guide for measuring the quality characteristics defined in ISO/IEC 2501n quality model division.

— ISO/IEC 25021 — **Quality measure elements**: provides a format for specifying quality measure elements and some examples of quality measure elements (QMEs) that can be used to construct software quality measures.

— ISO/IEC 25022 — **Measurement of quality in use**: provides measures including associated measurement functions for the quality characteristics in the quality in use model.

— ISO/IEC 25023 — **Measurement of system and software product quality**: provides measures including associated measurement functions for the quality characteristics in the product quality model.

— ISO/IEC 25024 — **Measurement of data quality**: provides measures including associated measurement functions for the quality characteristics in the data quality model.

Figure 1 depicts the relationship between this International Standard and the other International Standards in the ISO/IEC 2502n division. Developers, evaluators, quality managers, acquirers, suppliers, maintainers and users of target system/software product can select measures from these International Standards for the measurement of quality characteristics of interest. This could be for defining requirements, evaluating system/software products, performing quality management activities or for other purposes.

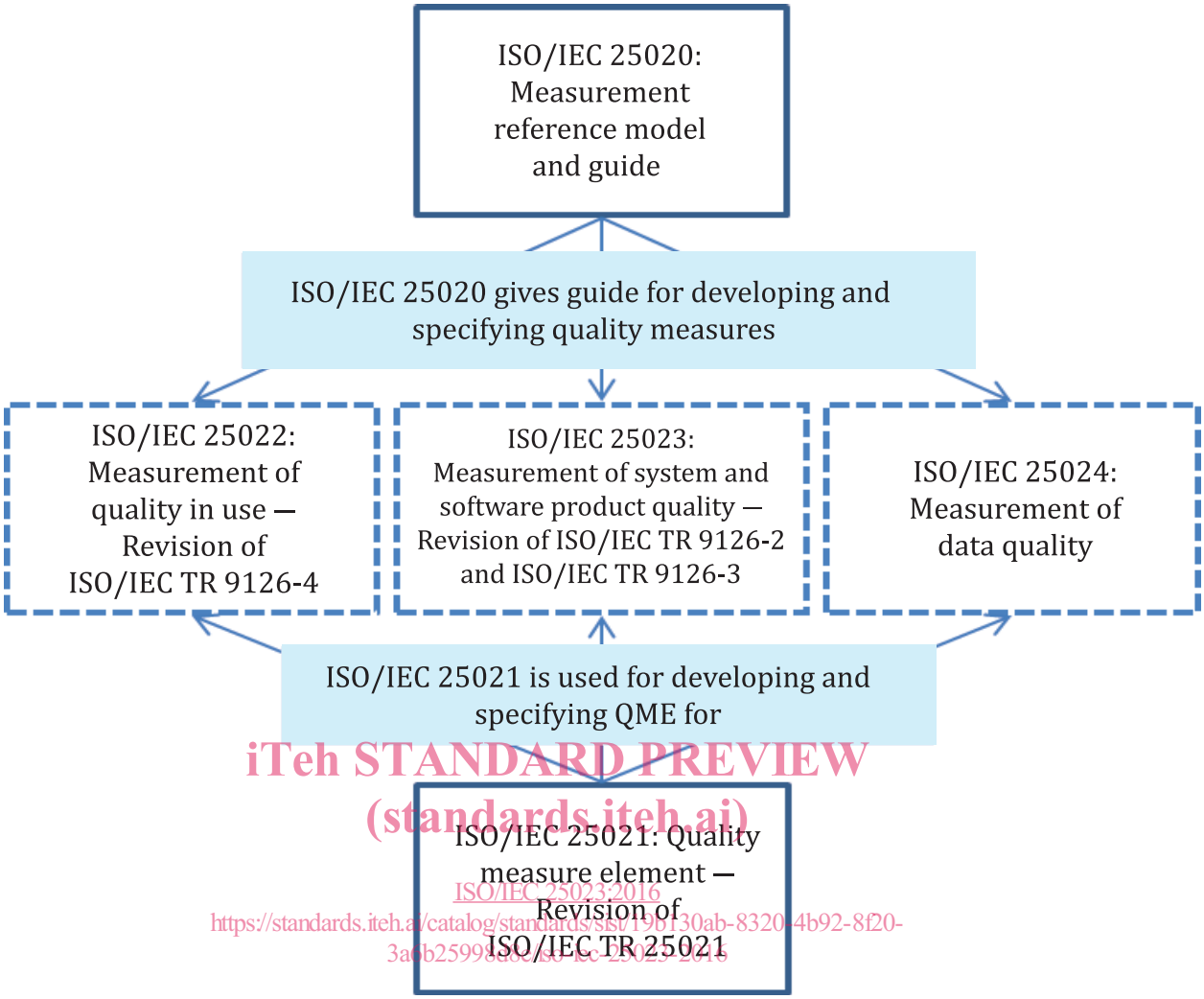


Figure 1 — Structure of the Quality Measurement Division

Outline and organization of SQuaRE series

The SQuaRE series consists of five main divisions and extension division. Outline of each divisions within SQuaRE series are as follows.

— ISO/IEC 2500n — **Quality Management Division**. The standards that form this division define all common models, terms, and definitions referred further by all other standards from SQuaRE series. The division also provides requirements and guidance for the planning and management of a project.

— ISO/IEC 2501n — **Quality Model Division**. The standards that form this division provide quality models for system/software products, quality in use, and data. A service quality model is under development. Practical guidance on the use of the quality model is also provided.

— ISO/IEC 2502n — **Quality Measurement Division**. The standards that form this division include a system/software product quality measurement reference model, definitions of quality measures, and practical guidance for their application. This division presents internal measures of software quality, external measures of software quality, quality in use measures, and data quality measures. Quality measure elements forming foundations for the quality measures are defined and presented.

— ISO/IEC 2503n — **Quality Requirements Division**. The standards that form this division help specify quality requirements. These quality requirements can be used in the process of quality

requirements elicitation for a system/software product to be developed, designing a process for achieving necessary quality, or as inputs for an evaluation process.

— ISO/IEC 2504n — **Quality Evaluation Division**. The standards that form this division provide requirements, recommendations, and guidelines for system/software product evaluation, whether performed by independent evaluators, acquirers, or developers. The support for documenting a measure as an Evaluation Module is also presented.

ISO/IEC 25050 to ISO/IEC 25099 are reserved for SQuaRE extension International Standards, which currently include ISO/IEC 25051 and ISO/IEC 25060 to ISO/IEC 25069.

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Measurement of system and software product quality

1 Scope

This International Standard defines quality measures for quantitatively evaluating system and software product quality in terms of characteristics and subcharacteristics defined in ISO/IEC 25010 and is intended to be used together with ISO/IEC 25010. It can be used in conjunction with the ISO/IEC 2503n and the ISO/IEC 2504n standards or to more generally meet user needs with regard to software product or system quality.

This International Standard contains the following:

— a basic set of quality measures for each characteristic and subcharacteristics;

— an explanation of how to apply software product and system quality measures.

It includes, as informative annexes, considerations for the use of quality measures (Annex A), QMEs used to define product or system quality measures (Annex B), and detailed explanation of measurement types (Annex C).

This International Standard does not assign ranges of values of the measures to rated levels or to grades of compliance because these values are defined based on the nature of the system, product or a part of the product, and depending on factors such as category of the software, integrity level, and users' needs. Some attributes could have a desirable range of values, which does not depend on specific user needs but depends on generic factors; for example, human cognitive factors.

The proposed quality measures are primarily intended to be used for quality assurance and improvement of system and software products during or post the development life cycle process.

The main users of this International Standard are people carrying out quality requirement specification and evaluation activities as part of the following:

— development: including requirements analysis, design specification, coding and testing through acceptance during the life cycle process;

— quality management: systematic examination of the software product or computer system, for example, when evaluating system or software product quality as part of quality assurance, quality control and quality certification;

— supply: a contract with the acquirer for the supply of a system, software product or software service under the terms of a contract, for example, when validating quality at qualification test;

— acquisition: including product selection and acceptance testing, when acquiring or procuring a system, software product or software service from a supplier;

— maintenance: improvement of the software product or system based on quality measurement.

2 Conformance

Any quality requirement specification or quality evaluation that conforms to this International Standard shall:

a) select the quality characteristics and/or subcharacteristics to be specified or evaluated as defined in ISO/IEC 25010;

b) for each selected characteristic or subcharacteristic, all the Generic (G) quality measures defined in Clause 8 should be used. If any are excluded, then provide a rationale;

c) optionally select any Specific (S) quality measures in Clause 8 that are relevant;

d) if any quality measure is modified, provide the rationale for the changes;

e) define any additional quality measures and QMEs as per ISO/IEC 25021 that are not included in this International Standard.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 25000, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE*

ISO/IEC 25010:2011, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models*

ISO/IEC 25021:2012, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality measure elements*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 25000 and ISO/IEC 25010 and the following apply.

NOTE The essential definitions from ISO/IEC 25000 SQuaRE series and the other ISO standards are reproduced here.

4.1
external measure (of system or software quality)
measure of the degree to which a system or software product enables the behaviour to satisfy stated and implied needs for the system including the software to be used under specified conditions

Note 1 to entry: Attributes of the behaviour can be verified and/or validated by executing the system or software product during testing and operation.

EXAMPLE The failure density against test cases found during testing is an external measure of software quality related to the reliability of the computer system. The two measures are not necessarily identical since testing may not find all faults, and a fault may give rise to apparently different failures in different circumstances.

[SOURCE: ISO/IEC 25000:2014, 4.11, modified]

4.2
internal measure (of software quality)
measure of the degree to which a set of static attributes of a software product satisfy stated and implied needs for the software product to be used under specified conditions

Note 1 to entry: Static attributes include those that relate to the software architecture, structure and its components.

Note 2 to entry: Static attributes can be verified by review, inspection, simulation and/or automated tools.

EXAMPLE The number of lines of code, complexity measures and the number of faults found in a walk through are all internal measures of software quality made on the product itself.

[SOURCE: ISO/IEC 25000:2014, 4.16, modified]

4.3
job
user-defined unit of work that is to be accomplished by a computer

[SOURCE: ISO/IEC/IEEE 24765:2010, 3.1542, modified]

4.4
measure
variable to which a value is assigned as the result of measurement

Note 1 to entry: The term "measures" is used to refer collectively to base measures, derived measures and indicators.

Note 2 to entry: In this International Standard, whenever the word "measure" is used qualified by a quality characteristic or sub-characteristic, it refers to a quality measure as defined in 4.8 below.

[SOURCE: ISO/IEC 15939:2007, 2.15, modified]

4.5
measurement
set of operations having the object of determining a value of a measure

Note 1 to entry: Measurement can include assigning a qualitative category such as the language of a source program (ADA, C, COBOL, etc.).

[SOURCE: ISO/IEC 15939:2007, 2.17, modified]

4.6
measurement function
algorithm or calculation performed to combine two or more quality measure elements

[SOURCE: ISO/IEC 25021:2012, 4.7, modified]

4.7
property to quantify
property of a target entity that is related to a quality measure element and which can be quantified by a measurement method

Note 1 to entry: A software artifact is an example of a target entity.

[SOURCE: ISO/IEC 25021:2012, 4.11, modified]

4.8
quality measure
derived measure that is defined as a measurement function of two or more values of quality measure elements

[SOURCE: ISO/IEC 25021:2012, 4.13]

4.9
quality measure element
QME
measure defined in terms of a property and the measurement method for quantifying it, including optionally the transformation by a mathematical function

[SOURCE: ISO/IEC 25021:2012, 4.14, modified]

4.10
quality model
defined set of characteristics, and of relationships between them, which provides a framework for specifying quality requirements and evaluating quality

[SOURCE: ISO/IEC 25000:2014, 4.27]

4.11
quality characteristic (of software product or system)
category of quality attributes that bears on software product or system quality

[SOURCE: ISO/IEC 25000:2014, 4.34, modified]

4.12
task
set or sequence of activities required to achieve a given goal

Note 1 to entry: These activities can be physical or cognitive.

Note 2 to entry: Role and responsibilities can determine goals and tasks.

[SOURCE: ISO/IEC 9241-11:1998, 3.9, modified]

5 Abbreviated terms

The following abbreviated term is used in this International Standard.

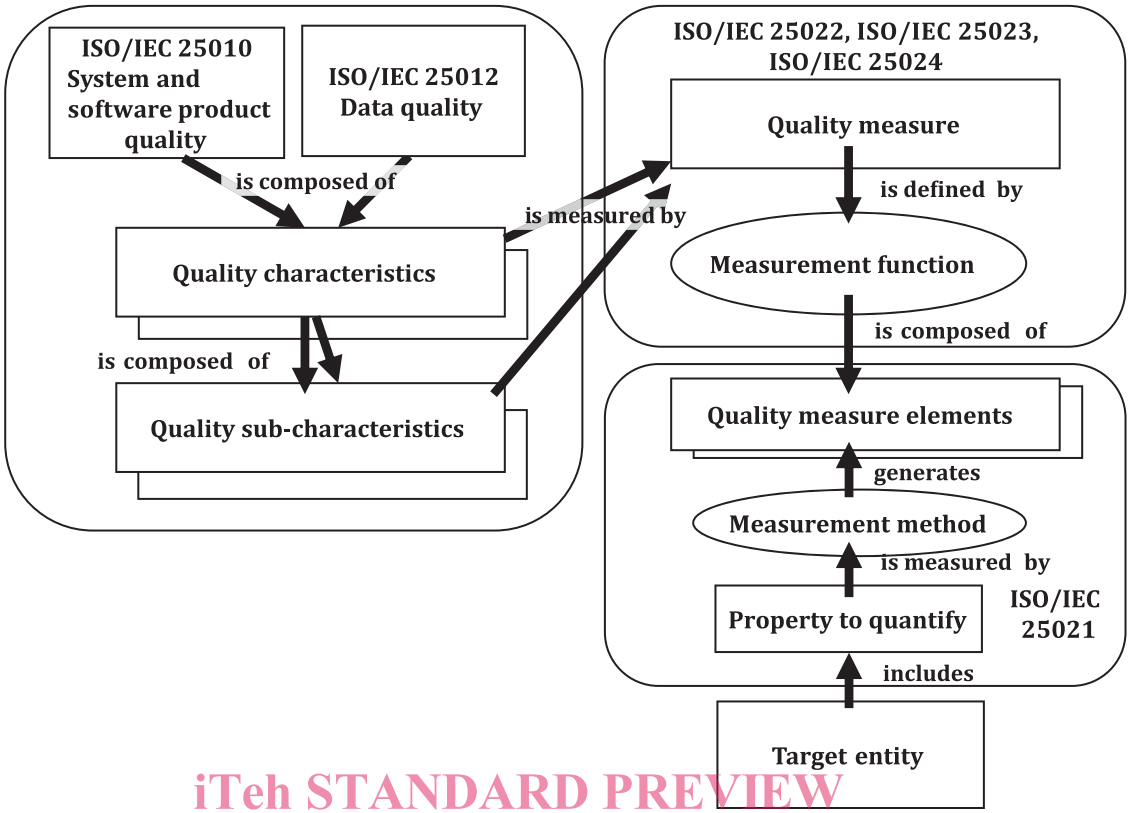
QME quality measure element

6 Use of system and software product quality measures

6.1 System/software product quality measurement concepts

The quality of a system/software product is the degree to which it satisfies the stated and implied needs of its various stakeholders, and thus provides value. These stated and implied needs are represented in the SQuaRE series of standards by quality models that categorize system/software product quality into characteristics, which in some cases are further subdivided into subcharacteristics. The measurable quality-related properties of a system/software product are called properties to quantify and can be associated with quality measures. These properties are measured by applying a measurement method. A measurement method is a logical sequence of operations used to quantify properties with respect to a specified scale. The result of applying a measurement method is called a quality measure element.

The quality characteristics and subcharacteristics can be quantified by applying measurement functions. A measurement function is an algorithm used to combine quality measure elements. The result of applying a measurement function is called a quality measure. In this way, quality measures become quantifications of the quality characteristics and subcharacteristics. More than one quality measure can be used for the measurement of a quality characteristic or subcharacteristic (see Figure 2).



NOTE Target entity can be a system, a software product, data or a user (see ISO/IEC 25010:2011, Figure 5).

Figure 2 — Relationship among quality model, QM, QME, property to quantify, target entity

6.2 Approach to quality measurement

User needs for quality include requirements for system quality in use in specific contexts of use. These identified needs can be considered when specifying external and internal measures of quality using software product quality characteristics and subcharacteristics.

Software product quality can be evaluated by measuring internal properties (typically static measures of intermediate products), or by measuring external properties (typically by measuring the behaviour of the code when executed), or by measuring quality in use properties (when the product is in real or simulated use). Appropriate internal properties of the software are a prerequisite for achieving the required external behaviour and appropriate external behaviour is a prerequisite for achieving quality in use (see Figure 3).

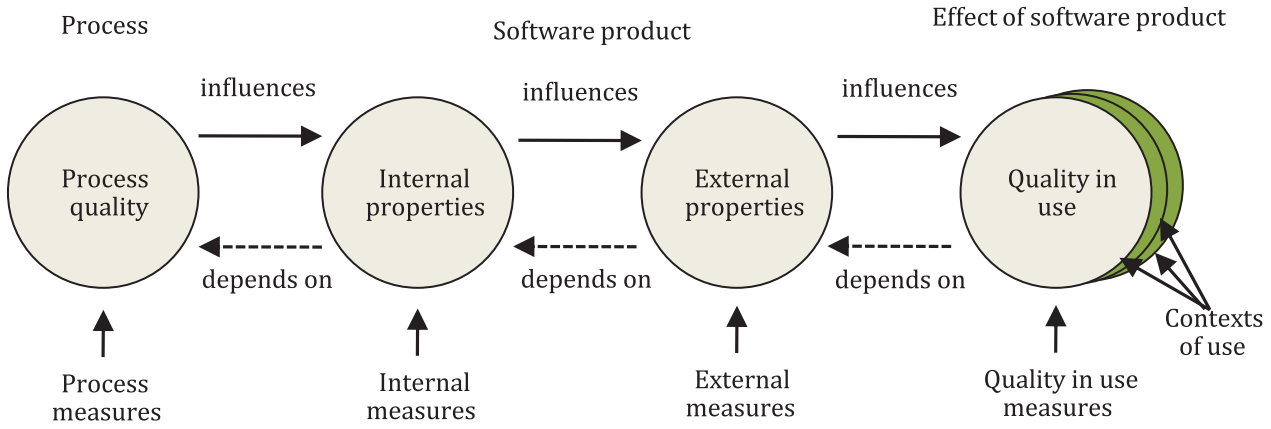


Figure 3 — Relationship between types of quality measures

The internal measures can be applied to a non-executable system/software product during its development stages (such as request for proposal, requirements definition, design specification or source code) which can be verified by review, inspection, simulation and/or automated tools. Internal measures provide the users with the ability to measure the quality of the intermediate deliverables and thereby predict the quality of the final product. This allows the user to identify quality issues and initiate corrective action as early as possible in the development life cycle. For example, complexity measures and the number, severity and failure frequency of faults found in a walk through are internal measures of software quality made on the product itself.

The external measures can be used to measure the quality of the system/software product by measuring the behaviour of the system of which it is a part. The external measures can only be used during the testing stages of the life cycle process and during any operational stages. The measurement is performed when executing the system/software product in the system environment in which it is tested and/or intended to operate. For example, the number of failures found during testing is an external measure of software quality related to the number of faults present in the computer system.

It is recommended, where possible, to use internal measures that have a strong relationship with the target external measures so that they can be used to predict the values of external measures.

This International Standard provides a suggested set of system and software quality measures (external and internal measures) to be used with the ISO/IEC 25010 quality model. The user of this International Standard can modify the quality measures defined and can also define and use quality measures not identified or defined in this International Standard.

NOTE 1 For example, the specific measurement of quality characteristics, such as safety or security, can be found in the International Standards provided by IEC 65 and ISO/IEC JTC 1/SC 27.

When using a modified or a new quality measure not identified in this International Standard, the user should specify how the measure relates to the ISO/IEC 25010 quality model or any other substitute quality model that is being used.

Most quality measures use a measurement function, which normalizes the result value within a range of 0,0 to 1,0. Closer to 1,0 is better. When this is not true, the interpretation is described in a NOTE.

Some quality measures produce a result that is relative to a target value that needs to be established as part of requirements.

NOTE 2 Some measurements are normalized against the target value specified in a requirement specification, a design specification, or a user documentation. Such target value is able to be determined and required as the threshold by developers or maintainers to improve architecture, design, implementation, assembles, operational procedures, user interface or performance of the software product or system. The target value is also able to be specified as one of agreed requirements by acquirers and suppliers to specify quality requirements or to examine conformance for acquisition. A requirements specification is usually changed and revised during development and affects the quality measures based on it. Some of requirements to be specified might be missing or inconsistent, or some of the target values might be insufficient and need to be changed because it is very difficult to specify completely both of stated and implied needs derived from stakeholder or system requirements at the beginning of development. Accordingly, users of quality measures are expected to take account of evolving and revising a requirements specification and to apply quality measures not at once but iteratively during development and/or evaluation.

NOTE 3 Some quality measures (such as mean response time) can be difficult to interpret in isolation. The following are ways that quality measures can be applied so that they are easier to understand and interpret:

a) conformance: comparing measures with a specific business or usage requirements (e.g. the maximum acceptable response time is 0,5 seconds);

b) benchmarks: comparing measures with a benchmark for the same or a similar product or system used for the same purpose (e.g. the mean response time of the new system in no more than the mean response time of the old system);

c) time series: comparing trends over time (e.g. how does the mean response time change during the day).

7 Format used for documenting the quality measures

The following information is given for each quality measure in the tables in Clause 8:

a) ID: identification code of quality measure; each ID consists of the following three parts:

— abbreviated alphabetic code representing the quality characteristics as capital X and subcharacteristics as one capital X followed by lowercase x (for example, “PTb” denotes “Time behaviour” measures for “Performance efficiency”);

— serial number of sequential order within quality subcharacteristic;

— G (Generic) or S (Specific) expressing potential categories of quality measure; where, Generic measures can be used whenever appropriate and Specific measures could be used when relevant in a particular situation;

b) Name: quality measure name;

c) Description: the information provided by the quality measure;

d) Measurement function: mathematical formula showing how the quality measure elements are combined to produce the quality measure.

NOTE Useful QMEs which can be used frequently to construct quality measures are specified briefly in Annex B to help comprehend and apply measurement function for the quality measures.

8 System and software product quality measures

8.1 General

The quality measures in Clause 8 are listed by quality characteristics and subcharacteristics in the order used in ISO/IEC 25010.

