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*Technical Report*

## Speech and multimedia Transmission Quality (STQ); Multi-component KPI



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***ETSI***

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

# Introduction

QoS testing, if done properly, requires considerable resources in time and personnel and is therefore costly. Consequently, efforts to increase productivity are an important part of technical evolution in this field.

There are some constants defining in the framework in which any such evolution has to work. The first and most important one is the requirement of testing from the customer's perspective. The second and equally important requirement is to provide statistical relevance, so to say the "quality of quality measurements".

Since, as operational experience shows, the dominant factor in cost of measurements is the time spent on these measurements, efforts focus on the question on how the time per data sample can be reduced, assuming that the number of data points should not be reduced to maintain statistical validity of results.

The requirement of testing from the customer's point of view restricts the space in which solutions can be found. Test cases cannot be modified arbitrarily; activities have still to reflect typical customer behaviour.

A possible solution is therefore multiple use of collected data. This is mainly based on the fact that today's popular data services (ftp, http, e-mail) all are internet-based which means that internet access is common to them.

NOTE: The concept of MCKPI is of course not limited to internet-based services or re-use of QoS data for internet access. The present document will, for practical as well as for didactical reasons, restrict itself on this issue.

The basic idea of MCKPI is now to use data collected in one type of test for KPI of another test also.

This is best explained with an example. Assume the following sequence of testing:

- Internet access (Attach, PDP context activation).
- ftp download.
- http web site download.

and calculating the TS 102 250-2 [i.1] KPI suite using the Internet access results both for ftp and http KPI.

From the above example it becomes clear that MCKPI is not only an operation in the mathematical domain of data processing; the advantage in terms of cost reduction for QoS measurements only materializes if the way tests are run is changed.

Such a far-reaching change in methodology and data processing needs, of course, careful consideration. The present document attempts to contribute to this consideration by providing facts, insights and discussion material on statistical and methodological aspects on MCKPI.

# 1 Scope

The present document discusses the concept of multi-component QoS KPI , their methods and validity rules.

The term Multi-component KPI (MCKPI) describes a KPI generated not from a single, continuous test case, but combined from results of different tests.

The motive to use MCKPI is to reduce cost and/or increase yield of measurement campaigns.

Aspects treated in the present document include:

- MCKPI concept and types.
- Statistical validity of MCKPI.
- Practical examples.

# 2 References

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Not applicable.

## 2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TS 102 250-2: "Speech Processing, Transmission and Quality Aspects (STQ); QoS aspects for popular services in GSM and 3G networks; Part 2: Definition of Quality of Service parameters and their computation".

# 3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

| | |
|---|---|
| DNS | Domain Name Server |
| KPI | Key Performance Indicator |

NOTE: Quality of Service parameter.

| | |
|---|---|
| MCKPI | Multi-Component KPI |
| PDP | Packet Data Protocol |
| PDPCA | PDP Context Acquisition |

# 4 MCKPI general concept

## 4.1 MCKPI framework

Many services in mobile communications have very similar structures if viewed from an end-to-end, macroscopic event flow perspective. For example, usage of all internet-based packet data services starts with obtaining network access (Attach), followed by principal packet data service access (PDP Context Activation) and in most cases also basic Internet access (e.g. DNS URL resolution).

From an "measurement effort" optimization point of view, the question arises if measurement results of such common elements obtained with one type of service can be re-used to provide results for another type of service, without actually measuring them.

For example, consider the following sequence:

- Service access (which may consist itself of several sub-phases).
- ftp test.
- http test.

and then using the service access results for generating both end-to-end KPI for ftp and http.

Of course, this will only work if the preceding steps of above sequence are successful. In that case, the yield of measurements would be much higher by skipping the service teardown phase after ftp, and the service access phase before http.

From the testing methodology, it means to run the service access sequence only when it is needed (i.e. after a breakdown of service access) and otherwise re-use existing connections.

Obviously, there are some pre-requisites which have to be fulfilled to even think of such a method:

- The sequence for which the MCKPI are computed is seamlessly described by component KPI.
- The pre-condition of having usable service access for dependent tests is properly validated (or it is implicitly given).

Later in the present document, we will see that there are other, less obvious aspects of validity of MCKPI. For the purpose of this introductory clause, we will however stay at this general level.

As a general remark, a certain type of MCKPI "philosophy" is contained even in the basic TS 102 250-2 [i.1] framework of KPI by defining "service independent KPI" in contrast to service-related KPI. Interpreting this as a methodological guideline, it allows to run "pure internet access" tests and use these results in arbitrary way.

## 4.2 MCKPI basics

There are two basic types of KPI and therefore also two types of MCKPI.

1) Success or failure rates

   A KPI of this type is expressed as the percentage of successful (positive KPI) or unsuccessful (negative KPI) tries with respect to the total number of tries.

   The following deals, for clarity, with success rates only. Failure rate computing is done accordingly.

   Assume that a full (real) test for a end-to-end KPI consists of n phases, and Ri is the success rate of the i-th phase.

   Then an overall success rate can be written as the product of individual success rates:

   $$R(e2e) = R0*R1*\ldots R(n-1)$$

   This becomes obvious if each success rate is written in its original form.

   $$Si = Si/Ti$$

   With S and T being the success count and the Tries count for this phase.

   If now T(i) = S(i-1), the product above can be shortened to:

   $$R(e2e) = S(n-1)/T0$$

   Which is exactly the formula for a conventional end-to-end success rate KPI.

2) Times

   Likewise, and not requiring mathematical formulae, the end to end time for a single instance of a service test is the time from start of the first phase to the end of the last phase, of course for the case that all phases have been passed successfully.



# 5 MCKPI technical aspects

## 5.1 MCKPI validity

The basic paradigm of MCKPI can be expressed verbally in a way such as "if a common phase is successful in a full test sequence of service A, it would also have been successful in a full test sequence of service B".

Or put in more concrete and practical form, since the internet service access does not "know" if it is used for subsequent ftp or http, its result can be "assigned" to both in an end to end test.

More generally, the single phases have to be independent.

The question now is, what means "independent"? Obviously, there is, strictly speaking, no such independence at all when taking into account that in tests of the type dealt with in QoS:

- the system under test is constantly changing, which means that doing the same test at times T1 and T2 cannot be expected to have the same result anyway: and worse
- in drive testing which is still a major part of overall testing, the testing system itself is not even at the same location at times T1 and T2.

At this point we should mention that there is one very fundamental aspect common to conventional testing as well as to MCKPI-inspired ones. This is, that the same radio network condition will produce different KPI results depending on timing.

To explain, imagine a network having a coverage "hole". Now assume a simple telephony drive test, in two differently "timed" versions.

In version 1, we try to set up the connection when we are inside the "coverage hole". Result will of course be a Failed Call.

Now change the timing slightly such that we have established the connection before we reach the "hole". In this case, our result will be a Dropped Call.

In STQ MOBILE meeting #18, a contribution (18TD10) was submitted - triggered by the MCKPI discussion - which deals with similar aspects, namely the question of statistical equivalence of different types of testing. This contribution shows results of numerical simulations on different dynamics of radio network quality over time or space (the full content is provided in annex A for convenience).

The conclusion of 18TD10 is:

- To get the same results for both methods, at least one of the following three requirements needs to be satisfied:
  - The KPI's are totally independent from each other (and thus also from the radio environment).
  - The radio environment is constant during the measurements.
  - The radio environment varies so fast during the measurements that consecutive actions can be assumed to have a totally independent radio environment.

Obviously the first condition can never be true since the course of testing action is directly influenced by the outcome of previous steps (this is however also true for conventional tests).

The second condition is of course only a "rhetorical" one.

The third condition, however, can be assumed fulfilled. Even if a single test result is neither "time" nor "space" independent in the strict meaning, it can be assumed that having enough samples will eliminate such effects for an overall KPI expressing the probability of a given result.

This does not mean the argument can be completely dismissed. There are two weaker "independence" type arguments which still need to be discussed:

- The first intrinsic assumption of MCKPI - see the example given some clauses above - is still that test phase activities are exchangeable in the following sense: We assume that as long as a service access, once established, is "intact" (proven by the successful completion of a service usage), it can be taken as if it has been "freshly" established.
- The second intrinsic assumption, being a different "flavour" of "time" independence in above sense is that successful conduct of a service usage means that a service access attempt would also have been successful if done instead.



Calling these two issues Objection No. 1 and 2, experience and logic both suggest that they are indeed "endangering" the practical usefulness of MCKPI.

Regarding Objection 1, in a test done by the author some time ago, it showed that for a particular network the service access "died" after a sequence of http web site downloads; the service access was "worn out". In a typical test conduct where each web download is preceded by a fresh service access, this would not have been observed. In a efficient MCKPI production scheme it could however lead to different results and therefore violate the basic assumption of component KPI re-usability of equivalence to real end to end tests. In any case, Objection 1 is relevant both for the mobile device and the network because both can show this kind of weakness.

Objection 2, while still serious enough, appears to be less severe. Firstly because we can expect it is only relevant to the network itself and less to the mobile device. Secondly, as hinted to above already, it is merely an aspect of the time dependency of test results present anyway.

In conclusion for the aspects of validity: Re-using test results in MCKPI definitely carries a certain residual risk; increasing test productivity may come with a higher - yet unquantified for the time being - uncertainty of results.

All considerations are of course based - as for conventional tests - on the assumption that only data from measurements done in comparable circumstances with respect to motion profile (e.g. drive, walk, stationary) and geographical environment (e.g. urban, rural) is used for computation.

## 5.2 MCKPI methodologies

It should be kept in mind that MCKPI is not just a way to compute results. To realize the potential benefits, it will necessarily have impact on how tests are run.

Remark: There is actually one way of using MCKPI on just the "result processing" level. This is again easiest shown with an example. Assume three "full end to end" service tests (ftp, http, e-mail) are run. Then, the results for internet access ( Attach, PDP Context Acquisition, DNS access) of each of these tests could be used to increase sample count and thus accuracy for related KPI. However, in the author's opinion this approach has very little practical value, because sample count for the first phases of a test case is anyway highest, so the accuracy bottleneck or weakest chain link will be the later phases which are service dependent anyway.

From a general analysis, there are at least three ways how MCKPI methods can be used in setting up practical tests:

- Running pure Internet Access tests (dense sequences of Attach, PDPCA and DNS) to achieve high spatial coverage of the area under test, and combine with long sequences with re-used internet access.
- Running sequences of same service type (e.g. ten times http) with the same internet connecting, re-establish only if needed.
- Running "cycles" of different services (e.g. ftp, http, email) with a single internet access used as long as possible.

## 5.3 Extending MCKPI to non-seamless tests

So far, "strict" seamlessness of tests with respect to the phases a transaction consists has been assumed. An important aspect of this picture is that the starting condition for a phase is equal to the condition for of successful completion of the preceding phase.

However, in practice, if combining service usages with common preceding phases, it has to be taken into account that "gaps" can occur, in the simplest case by pauses between phases.

The following questions have to be discussed:

- Can "gaps" between phases be tolerated, and what are the conditions for that?
- Which additional steps to secure fulfilment of initial conditions have to be taken into account?

Validating starting conditions are, in general, taking time and may also contain additional activities (e.g. DNS accesses to secure intactness of an internet connection) which are not present in "real" customer-perspective transactions.

In this sense, we may differentiate between "passive" pauses which just come from inevitable procedure steps, and "active" pauses" where additional activities take place.

It should be noted that this issue is considered by the STQ MOBILE group as requiring further study.

# 6 Summary and conclusion

In the previous clauses, we have dealt with validity aspects and methodological implications of MCKPI.

MCKPI schemes can reduce the testing time for a given number of samples for a particular service, or it can be used to increase the number of samples - or the spatial precision in case of drive tests - for a given testing time.

It has been shown that the concept of MCKPI may be useful but comes with some caveats and even some risks. It is very likely that part of the net gain in measurement productivity has to be spent again in securing result validity by doing more in-between validation of preconditions for individual phases of tests.

However, if used wisely, MCKPI may improve testing efficiency and therefore contribute to cost saving and/or better quality of measurement results.