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SERIES M: MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

International public telephone network

Method to improve the management of operations and maintenance processes in the International Telephone Network

ITU-T Recommendation M.1230

(Previously «CCITT Recommendation»)

ITU-T M-SERIES RECOMMENDATIONS

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FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation M.1230 was revised by ITU-T Study Group 4 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 12th of May 1996.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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ABSTRACT

This Recommendation describes general guidelines for Telecommunications Operators in order that they can improve the QOS and NP through the optimization of Operation and Maintenance (O&M) processes focusing on the customer satisfaction of the telephone service. The proposed method foresees the correlation between the assessment performance results of the international telephone network with a general index which represents the difficulty levels of O&M environment.

KEYWORDS

Context Difficulty Index (CDI), Customer, Maintenance, Network Performance (NP), Operations, Operations and Maintenance (O&M) processes, Quality of Service (QOS), Telecommunications Operator (TO) – Administrations, ROAs, Carriers, etc.

METHOD TO IMPROVE THE MANAGEMENT OF OPERATIONS AND MAINTENANCE PROCESSES IN THE INTERNATIONAL TELEPHONE NETWORK

(Melbourne, 1988; revised in 1996)

1 Scope

This Recommendation provides a reference model which includes both the description of the main parameters and different methods to assess the network performance. The description of a Context Difficulty Index (CDI) which is related to several components of the network and the O&M environment is also provided. It is possible to evaluate the service level performance from CDI and thus decide for any change or intervention as required to improve the perceived quality of the service to the customer.

It is not the intention of this Recommendation to:

i) suggest any particular method or technology for the assessment of the network performance;

ii) standardize any specific O&M process (e.g. internal organization, O&M procedure, etc.);

iii) establish any specific objectives, target and thresholds for QOS and NP parameters;

iv) set any level of Customer Satisfaction.

The choice or decision on all the above issues is left to individual TO or to specific arrangements between TOs (e.g. when TOs jointly establish formal Service Quality Agreements with the major aim to develop mutually acceptable performance standards and to enable customer expectations to be met [14]).

2 General

With the increased liberalization and consequent competitive telecommunication scenarios, there is an increased need to find out in various ways how the network is performing to meet customer expectation. All Network and/or Service Providers, who in the past provided only network capacity and then maintained performance level by using different maintenance methods specified in ITU-T Recommendations, are now more and more focused on the improvement of NP and QOS[1] as experienced by customers.

To meet these main objectives, each TO has introduced and developed a wide range of test procedures and quality assessment methods[2] in order to test the network both objectively and subjectively and to ensure a better and better QOS to their customers [1] to [20].

It is also very important to note that modern telecommunication systems have a great deal of built-in facilities through which it is possible to ensure a continuous and automatic supervision of performance parameters.

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1) **QOS** is defined as "the collective effect of service performance which determines the degree of satisfaction of a user of the service" [16]. Thus QOS is of concern to the user of the Service Provider. When the Network Provider is also the Service Provider he is responsible for the QOS.

2) Continuous interrelationship and exchange of information in this area is necessary between ITU-T SG 4 and SG 2. In fact many Recommendations of E-Series describe QOS and NP concepts, parameters and methods for their measurements and they also contain suggestions on how to establish Service Quality Agreements [14] and also Customer Satisfaction Point [13] between Telecommunications Operators.

3 Assessment of network performance from the point of view of maintenance

Network Performance (NP) is a statement of the performance of connection element or concatenation of connection elements employed to provide a service and it is defined and measured in terms of parameters which are meaningful to Network Providers for different purposes [16]. Furthermore, it is to be noted that NP is defined independently of terminal performance and customer's actions and it is also service independent in that it must be able to support all the services the particular network is required to transport.

The QOS experienced by a customer is a very broad concept and depends on a combination of factors some of which are not under the direct responsibility of maintenance staff, for example:

- calling and called customer behaviour (i.e. percentage of non-successful calls related to premature abandonment or not answered calls for various reasons such as ring tone no answer, busy tone received or subscriber busy, etc.);

- planning and provisioning of the network and whether sufficient network resources (i.e. circuits, switching equipment) are provided to meet the number of call attempts by customers (e.g. percentage of non-successful calls due to lack of trunks/circuits);

- the degree to which network management or any other control system or tool is employed.

It should be emphasized that the assessment of network performance is of primary importance to Network Providers for the "efficient maintenance" of their international telephone network [19].

Therefore, it is very important to assess the network performance through end-to-end measurements and to collect all results in order to activate any corrective maintenance action as needed to re-establish the level of performance as required.

From the point of view of Maintenance, the assessment of international telephone network performance involves a measurement of the capability of the overall network (end-to-end, i.e. international section plus two national sections), to establish a switched connection of good transmission quality whenever required.

The general reference model for overall (end-to-end) measurements is reported in Figure 1.

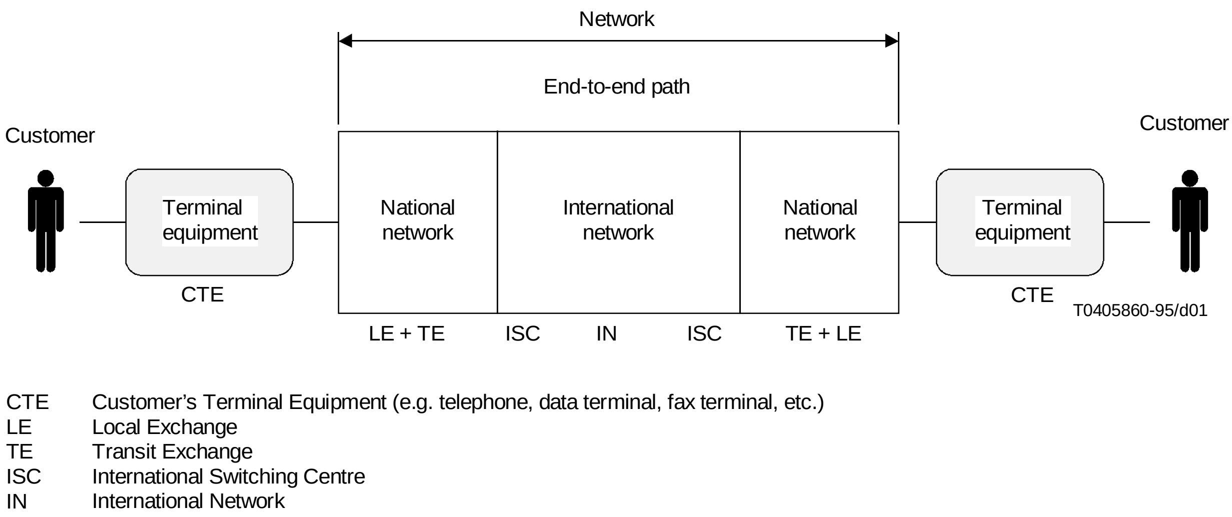


FIGURE 1/M.1230

Reference model for overall (end-to-end) measurements

4 Major NP parameters for end-to-end measurements

According to existing Recommendations, the parameters essential to objectively measure the Quality of Service as perceived by customers, may be categorized into two main areas [12]:

a) *Call connectivity*

The essential parameters required to assess the connectivity quality are:

- Start Dial Signal Delay (SDSD);
- Call disposition (e.g. reasons for unsuccessful call completion, e.g. wrong number, unknown tone, congestion, etc.);
- Post Dialling Delay (PDD);
- Call Completion Rate [or Answer Seizure Ratio (ASR)].

Call failures are categorized as due to network faults, equipment failure and network congestion.

b) *Transmission quality*

The essential parameters contributing to the transmission quality (call clarity) are:

- Transmission loss;
- Attenuation distortion;
- Total distortion;
- Group delay distortion;
- Idle channel noise;
- Impulsive noise;
- Round-trip delay;
- Echo;
- Clipping.

It is important to note that for compatibility between manufacturers and TOs, it is essential to have a common measurement methodology[3]. This will ensure that measured results are comparable between TOs and thus it will improve their cooperation in all joint activities and also the quality of the telephone service as offered to mutual customers.

As examples of network parameters, a list of main parameters for voice and non-voice calls is given below. This is not an exhaustive list.

Voice

– Circuit loss;
– Circuit noise;
– Impulsive-noise;
– Cross-talk (unintelligible);
– Terminal balance;
– Echo, control devices, delay, loss, stability;
– Propagation time, digital processing;
– Impedance mismatch;
– Quantization, non-linear and attenuation distortions and bandwidth;
– Speech detectors parameters, switched loss clipping, interruptions, freeze-out, fading;
– Power loads on cables and carriers, leakage, imbalances.

[3] This requires further study/definition.

Non-voice

- Impulsive-noise, frame slips, jitter, hits, drop-outs, distortion, circuit loss, cross-talk, interruptions;
- Burst errors;
- Echo;
- Delay;
- Out of synchronism;
- Noise;
- Group delay distortion.

5 Review of present methods for assessing overall (end-to-end) network performance

At present the following methods of measuring international telephone networks are available.

5.1 Test calls methods (intrusive measurements)

There are currently four types of test calls which can be carried out both manually or automatically to assess the functioning of international circuits, namely [4]:

a) *Type 1 test calls*

These test calls are conducted between two directly connected international centres to verify that the transmission and signalling performance on an international circuit of a given group are satisfactory.

b) *Type 2 test calls*

These test calls are conducted between two international centres not directly connected to verify transit operational facilities of an intermediate international centre.

c) *Type 3 test calls*

These test calls are conducted from an international centre to a subscriber type number in the national network of the distant country (in general as a result of a particular kind of fault).

d) *Subscriber-to-subscriber type test calls*

These type of test calls are conducted with test equipment having the characteristics of an average subscriber line in one national network to similar equipment in the national network of a distant country.

The main existing Recommendations that describe subscriber-to-subscriber end-to-end measurements are:

- **Recommendation M.1235 – "Use of automatically generated test calls for assessment of network performance" [20]**

  This Recommendation describes the use of automatic subscriber-to-subscriber test calls performed either in system-independent test call generators and test call responders, or by built-in facilities performing the same functions. Call-through testing as described in this Recommendation, can be used to check the performance on routes, circuits, switches and associated equipment. It should be noted that these test calls programmes should be carried out both during non-busy and busy periods and they have to be carefully planned. This means they have to be agreed between TOs concerned in order to avoid any kind of interference by a contemporaneous use of the same test number for other utilization. In this Recommendation are also defined the criteria for the choice of the number of test calls to be generated towards each switched destination and as it is stated, this number is mainly dependent on the frequency of difficulties encountered towards a certain destination (i.e. fewer test calls are needed to identify the network performance level when the rate of difficulties encountered is high).

– **Recommendation E.434 – "Subscriber-to-subscriber measurements of the public switched telephone network" [12]**

  This Recommendation defines the methods and processes for testing, the measurements required, the elements of an end-to-end system and the operation of an end-to-end system, and it also contains Recommendations to define interfaces and protocols.

  It is to be noted that also in this Recommendation the number of test calls depends on the parameters to be measured and the desired accuracy for those parameters. Further the number of test calls should be large enough to provide statistically valid results within the desired accuracy for each parameter measured, and small enough to allow the data to be collected over a fairly short period of time. Particular consideration should be given to trunk size of traffic volumes on the route when test call quantities are being determined.

  Another consideration (limitation), is to keep the best period for measurements relatively short to ensure the availability of the test device, and therefore to avoid conflicts that might result in the use of responders. It is important to observe that "such conflicts" could also have an impact on the accuracy of results as test calls may have failed to complete because the terminating responder was in use for a different test programme rather than a real network failure.

  In conclusion, also this method requires careful coordination and scheduling for test calls programmes between the TOs concerned.

5.2 Service Quality observations (non-intrusive measurements)

Another way of supervising the total through connection capabilities of the network is to make Service Quality observations. The definition of "Service observation" [2] is the following: "Monitoring to obtain a complete or partial assessment of the quality of telephone calls, excluding test call".

There are three methods to perform service observations:

– Manual observations – This is the monitoring of telephone calls by an observer without using any automatic data-recording machine.

  This method provides all the data required in specific tables, namely: Table 1/E.422 [3] and Table 1/E.423 [4]. With this method, observations can be carried out with a minimum of equipment. Furthermore observations can allow the detection of a number of abnormalities that cannot be detected automatically (e.g. very poor speech transmission, or difficulty with audible tones).

– Semi-automatic observations – This is the monitoring of telephone calls using equipment that records some data automatically (e.g. equipment such as exchange, in which information being observed, number dialled by the subscriber, metering pulses and time of call, is recorded automatically on some means suitable for data processing).

  This method also provides all data required in Tables 1/E.422 and 1/E.423, but a greater accuracy compared with manual observation is possible because there is an automatic recording of the number dialled, the time of the call, etc. In addition, it is possible for the observer to devote greater attention to the more critical conditions being checked during observations of calls.

– Automatic observations – This is the monitoring of telephone calls without an observer.

  This method allows: continuous observation, a larger sample, to process data automatically, etc.

There are two types of automatic observations:

i) Internal automatic observations that can be made in the switching centre itself (on the incoming side or the outgoing side or in between).

   Main considerations of this method are: Only line signalling, such a seizure, answer, etc. can be monitored and also register signals as long as they do not pass through the exchange in an end-to-end signalling procedure; signals received are monitored if the exchange itself operates correctly in that respect and this also applies to the outgoing signal.

This observation technique is described in Recommendation E.425 [6], where it is underlined that its major advantage is that a large volume of call records can be collected and because a large volume of data can be obtained, this allows a day-to-day evaluation of Network Performance. The type of data collected can be related to effective network problems and calling and called subscriber behaviour [Call Failure Code Analysis (CFCA)]. Nowadays, the usefulness of such CFCA for CCSS No. 7 analysis is more and more increasing in line with the worldwide introduction of CCSS No. 7 in the national and international networks. It is to be noted that daily analysis of this information is of great importance in trouble detection, and coupled with a good maintenance response, it represents a powerful means to provide the best quality of service. The disadvantage is that this method does not have the capability of detecting tones or speech and therefore cannot present a complete representation of all call dispositions. To overcome this disadvantage it is recommended to use this method with Recommendation E.422.

ii) External automatic observations that are made by means of monitoring equipment that is supervising the traffic on incoming and outgoing lines. With this technique all signalling signals can be monitored, the detection of tones, speech and data is possible if advanced equipment is used. It also provides the data required in Tables 2/E.422 and 2/E.423 and as its application is very flexible it can be used instead of manual or semi-automatic observation techniques.

5.3 Considerations of the methods of network performance assessment

The attention of the TOs is drawn to the following:

1) The above methods are not exclusive. The nature of information obtained (e.g. verification of call completion rate, transmission quality, influence of international and national sections) will depend on the method of Network Performance assessment employed.

2) While there is a recognized need to continuously assess the performance of the international telephone network, the actual method by which this is achieved depends upon the arrangements within and between TOs and on the switching technology employed.

3) The choice of methods is left to individual TOs, to decide on the basis of their own particular circumstances. Information obtained (e.g. verification of call completion rate, transmission quality, influence of international and national sections) will depend on the method of Network Performance assessment.

6 General method for the optimization of the Operations and Maintenance (O&M) processes

Against the background of present network developments, the major aim of a TO is to move towards the implementation of integrated telecommunications and relevant management systems in order to properly manage the level of network performance and Quality of Service and optimizing the related costs for all the processes involved.

This is very important for the overall O&M process where the performance of each constituent part is to be carefully handled in order to ensure efficiency and effectiveness of all resources (systems, personnel, internal organization, etc.) involved in the process.

For example in the “maintenance” process the resources are represented by both the network and human resources. For the network the major components are: type and technological implementation of network elements (i.e. transmission and switching facilities, supervisory and measuring equipment). For human aspects the major components are: the staffing sufficiency and the skill levels.

Thus for the O&M process it is necessary to:

1) Manage the Network Performance (and then the QOS) level through the knowledge of the standards of different call connectivity and transmission quality parameters as measured utilizing one or a combination of the previous methods of network performance assessment as described in Clause 5.

2) Manage the Operation and Maintenance performance through the knowledge of relevant appropriate parameters; for example the billing error ratio [11], the failure rate, the Mean Time to Repair (MTTR), the Service provisioning rate, the Directory response ratio, etc. [17], [18], [21].

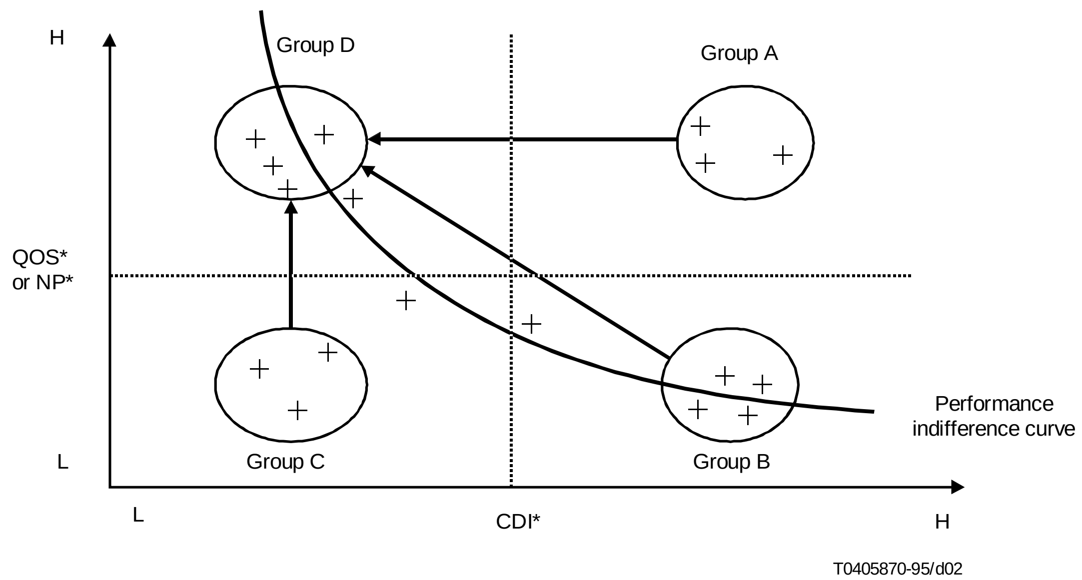
3) To define and utilize an overall index CDI (Context Difficulty Index) which represents the difficulty levels (i.e. the non-performance) for all processes/components involved in the O&M environment. An example of a CDI related to a particular "Transmission environment" is attached to this Recommendation as Annex A, where the most CDI significant components are defined and also its computations are shown.

It is important to note that NP (QOS) varies inversely with CDI, e.g.:

– when the environment is good (CDI low), NP (QOS) is high;

– when the environment is bad (CDI high), NP (QOS) is low.

If the management capability of all components involved are comparable, the relationship of NP (QOS) and CDI is on the performance indifference curve as shown in Figure 2. However, there are some abnormal cases such as Group A and Group C. In Group A, the environment is bad (CDI high), but its NP (QOS) is high. This may be explained by the fact that the management capability of different components concerned is excellent. In Group C, the environment is good, but their NP (QOS) is low. Therefore, these components appear to have problems in the management procedures, or there could be other reasons for low performance.



QOS* QOS standard value
NP* NP standard value
CDI* CDI standard value

FIGURE 2/M.1230

Management model for performance

It is clear that the best choice for TOs is to keep all the involved components in Group D, where the environment is good (CDI low) and NP (QOS) is high.

As an example to achieve the aforesaid goals, the NP (QOS) and CDI relationship should be used to determine O&M budgets and relevant actions should be taken as follows:

1) *Group A* – Even though the CDI is high, the NP (QOS) is high. Thus incentives should be given to the managers of these components, and O&M budgets should be assigned with high priority to improve their environment. With these relevant actions, it is possible to provide positive motivations to other components which have high CDI.

2) *Group B* – They are in the performance indifference curve, but below the NP (QOS) standard value NP* (QOS*). Therefore, additional budgets should be assigned to improve the NP (QOS) and CDI. With continuous supports, NP (QOS) and CDI should be improved above their standard values.

3) *Group C* – NP (QOS) is low even though the CDI is low. In this case relevant actions should be taken not by budget assignment but by management consulting to find reasons for low performance. Their NP (QOS) should be improved above standard value with proper activities.

4) *Group D* – These are ideal cases. With continuous support, it is essential to keep the NP (QOS) and CDI of these components above the standard values.

Annex A

Example of Context Difficulty Index (CDI) in an O&M environment where transmission aspects are predominant

(This Annex forms an integral part of this Recommendation)

In this "transmission environment" the following four significant factors are identified:

i) *Feeder cable ratio* – "Percentage of non-feeder cable to the percentage of feeder cable uninstalled area".

ii) *Cable buried ratio* – "Percentage of buried cable from the total cable".

iii) *Staffing insufficiency level* – The lack of personnel from its assigned number.

iv) *Facility-obsolete level* – The level of obsoleteness for key facilities.

When the CDI value is high, it represents that the O&M environment is not good.

These four factors can be selected, as they are important and common problems and their relevant data could be easily collected. CDI values can be calculated as reported in the following computation method.

Four CDI component index:

1)	Feeder cable ratio	X1	→	Feeder cable index	Y1 = F(X1)
2)	Cable buried ratio	X2	→	Cable buried index	Y2 = F(X2)
3)	Staffing insufficiency level	X3	→	Staffing insufficiency index	Y3 = F(X3)
4)	Facility obsolete level	X4	→	Facility obsolete index	Y4 = F(X4)

F Transform context difficulty component values into an index which has a range[4] from 1 to 5.

CDI computation:

$$CDI = (Y1 + Y2 + Y3 + Y4)/4$$

[4] For each central office as involved in this example, values of context difficulty components were computed. Then central offices were classified into five different ranges according to these values. The offices with the best environment are assigned with index 1 and the poorest are assigned index 5. Thus, if CDI is high, their O&M environment is poor, if CDI is low, their O&M environment is good.

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