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SERIES O: SPECIFICATIONS OF MEASURING EQUIPMENT

Equipment to perform measurements on leased-circuit services

Framework for end-to-end QoS measurement and supervision for leased-circuit services

ITU-T Recommendation O.220

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ITU-T Recommendation O.220

Framework for end-to-end QoS measurement and supervision for leased-circuit services

Summary

ITU-T Recommendation O.220 describes the overview of the end-to-end QoS measurement and supervision mechanisms, which can be used to carry out SLA guarantee. Several options for the end-to-end QoS measurement and supervision mechanisms are provided.

Source

ITU-T Recommendation O.220 was approved on 16 March 2007 by ITU-T Study Group 4 (2005-2008) under the ITU-T Recommendation A.8 procedure.

Keywords

End-to-end, probe, QoS, SLA.

FOREWORD

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ITU-T Recommendation O.220

Framework for end-to-end QoS measurement and supervision for leased-circuit services

1 Scope

When a service provider (SP) plans to provide a service to a key customer with QoS guarantees using an SLA, some measures should be taken to monitor the end-to-end QoS provided to the customer, so that it is possible for the SP to know whether the SLA has been violated or not during the whole lifetime of the service.

The purpose of this Recommendation is to introduce an architectural framework, supporting end-to-end QoS monitoring functionality. This functionality can be achieved in multiple ways. NE with built-in capabilities is one choice for those network technologies that support it, and stand-alone instrumentation is another choice, which can be applied to the network technologies that do not provide this functionality within their own technologies. It is the intention of this Recommendation to provide solutions which do not influence the network elements.

This Recommendation provides an overview of end-to-end QoS measurement and supervision architectures. Within its scope, it provides an overview of:

- problems currently experienced when carrying out end-to-end QoS measurement and supervision for a network service;
- considerations for the localization of the responsibility when a SLA is violated, either due to network side problems or to customer side problems;
- general recommendations for the mechanisms of the end-to-end QoS measurement and supervision using measurement instruments (such as probes); and
- other considerations for selecting end-to-end QoS monitoring and supervision mechanisms using probes.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T E.860] ITU-T Recommendation E.860 (2002), *Framework of a service level agreement*.

[ITU-T M.3208.1] ITU-T Recommendation M.3208.1 (1997), *TMN management services for dedicated and reconfigurable circuits network: Leased circuit services*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 service level agreement (SLA): [ITU-T E.860].

3.1.2 leased circuit service (LCS): [ITU-T M.3208.1].

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 QoS probe: A measurement and test instrument that can be used to monitor alarms and collect QoS parameters in a network in real time.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AIS Alarm Indication Signal

ATM Asynchronous Transfer Mode

DCN Data Communications Network

DDN Digital Data Network

EMS Element Management System

ES Errored Second

IP Internet Protocol

LCS Leased Circuit Service

LOF Loss Of Frame

LOS Loss Of Signal

NE Network Element

OS Operating System

PCM Pulse Code Modulation

QoS Quality of Service

SC Service Customer

SES Severely Errored Second

SLA Service Level Agreement

SP Service Provider

TMF TeleManagement Forum

US Unavailable Seconds

5 Conventions

None.

6 Overview

6.1 Introduction to the service environment of LCS

The current services provided on leased circuit to key customers mainly include (but are not limited to) the following:

– 2M digital circuits (for IP or PCM);
– DDN;
– ATM;

– X.25;
– Frame relay.

6.2 Purpose of QoS monitoring and supervision for LCS

In general, the purpose of the QoS monitoring and supervision is to:

– monitor the performance parameters, detect faults in real time and generate QoS reports, in order to know the running status and QoS level of the circuits provided to customers;
– support QoS reporting to key customers with an SLA;
– help locate faults occurring in the network quickly and precisely;
– fast locate the responsibility for a specific QoS degradation. Some service problems are not occurring at the network side, but at the user side, which is outside the scope of the end-to-end LCS, and should not be counted as LCS QoS degradation; and
– try to provide better technical support to key customers.

6.3 Problems with QoS monitoring and supervision in the traditional way

Traditionally, a network management system (NMS) collects performance data from element management systems (EMSs) and network elements (NEs) directly, and then analyses the QoS of the transport part of the leased circuits according to the collected data.

Limitations of the system implementations could create obstacles which are difficult to overcome:

– Hardware and software implementation choices in traditional EMSs or NEs put limits on their performance when executing all the performance monitoring tasks, possibly resulting in performance degradation of managed systems or even telecommunication services of the NEs.
– No end-to-end QoS parameters are provided for a specific customer, as there is no specific instrument positioned for a specific customer.
– With the traditional way of QoS data measurement, precise fault location may be difficult.

7 Basic requirements for the functions of end-to-end QoS monitoring

In order to support end-to-end QoS monitoring for an LCS, the following functional requirements should be supported by a QoS measurement mechanism:

– real-time collection of QoS data for an end-to-end service;
– the end-to-end QoS monitoring shall provide means to collect QoS data for a specific service customer (SC);
– detection for QoS-related problems at both customer side and network side;
– there shall be mechanisms for a QoS measurement instrument to transfer its monitored result to the network management systems (directly or indirectly);
– the end-to-end QoS monitoring mechanisms shall be controlled by management systems (such as an NMS or an EMS); and
– the interfaces for exchanging management information between QoS measurement instruments, or between QoS measurement instruments and management systems, shall be provided.

A list of the alarms and QoS parameters that may be monitored for end-to-end QoS monitoring can be found in Appendix I.

8 Overview of end-to-end QoS monitoring and supervision mechanisms

In order to solve the problems encountered in the traditional way of QoS measurement as mentioned in clause 6.3, and to meet the requirements as listed in clause 7, some proposed architectures and considerations for the end-to-end QoS monitoring and supervision are provided in the following clauses, and will be described in three aspects, namely:

– introduction to QoS probes;

– deployment of the measurement instruments; and

– connection methods between QoS measurement instruments and management systems.

The combination of the three aspects will result in several end-to-end QoS monitoring and supervision mechanisms.

9 Introduction to QoS probes

9.1 Functional description

QoS probes are stand-alone measurement instruments used to monitor the QoS information of a specified circuit(s). A QoS probe is able to provide the following functions:

– collect the specified QoS parameters from the monitored circuit(s);

– transfer the collected QoS data to the network management systems;

– help to locate the fault position in the monitored circuit(s).

9.2 The purpose of using QoS measurement instruments for end-to-end QoS monitoring

The purpose of introducing measurement instruments, such as QoS probes, is to solve the issues in end-to-end QoS monitoring which the traditional performance management cannot easily solve. The purposes and the benefits are summarized in the following list:

1) From the perspective of hardware system performance, they can improve the overall performance of end-to-end QoS monitoring, because it is more efficient to install one or more QoS probes for the desired measurement points than improving the overall processing capability of the EMSs, and there is no need to change the current serving NEs that do not provide powerful QoS monitoring capabilities.

2) The traditional QoS parameters are mainly monitored from the network perspective, and the focus is not on individual services from the end-to-end QoS perspective. It is difficult to provide the QoS parameter data for a specific LCS SC. When QoS probes are applied for the end-to-end QoS monitoring, it will be much easier to collect the end-to-end service parameters that are specific for a customer, as QoS probes can be designed to provide the capability for monitoring dedicated QoS parameters for one or more LCS SCs at the same time.

3) As the traditional QoS monitoring mechanisms are mainly focusing on the detection of network problems, when there is a QoS complaint from a SC, it is usually very hard to make a decision on whether the QoS degradation or service unavailability is caused by the SP's network or by the SC oneself. A QoS probe located at the edge between the SC's network side and the SP's network side can provide effective evidence to decide which party is responsible for the service degradation or service unavailability.

4) Based on the end-to-end QoS data for individual SCs collected from various QoS probes, the corresponding QoS report for each SC with QoS guarantee can be generated.

5) Using dedicated probes provides flexibility; refer to clause 11 for the various methods for collecting QoS data and transferring it to the management systems.

9.3 Connection methods between a QoS probe and the monitored network

Basically, there are two methods for connecting measurement instruments (QoS probes): parallel connection and serial connection.

9.3.1 Parallel connection

Figure 9-1 shows the case where a measurement instrument is parallel-connected to the circuits to be monitored. In this connection method, a measurement instrument does not have any influence on the circuit, it can only "read" the status of the circuit line and perform the QoS measurements and monitoring functionalities.

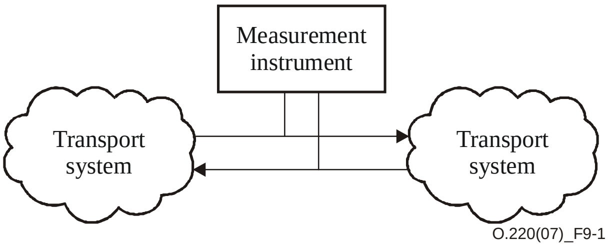

Figure 9-1 – A measurement instrument parallel-connected to the transport line

9.3.2 Serial connection

Figure 9-2 shows the case where a measurement instrument is serially connected to the circuits to be monitored. In this connection method, a measurement instrument gets data frames from its upstream node and transfers them to the downstream node. During this procedure, the measurement instrument may send extra information downstream; i.e., it has the opportunity to change certain parts of the data stream before forwarding it through the transport channel.

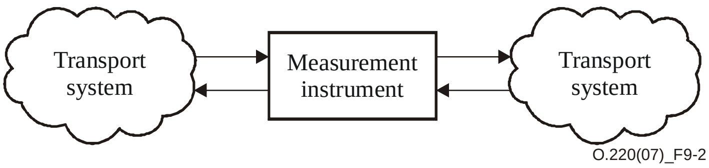

Figure 9-2 – A measurement instrument serially connected to the transport line

10 Deployment of measurement instruments

The deployment of the measurement instruments in a transport network influences the effects of the end-to-end QoS monitoring. Based on different purposes, the position of deploying the measurement instruments can be divided into the following two types:

– in the middle of an network;

– at the edge of the SP's network.

10.1 In the middle of the network

Figure 10-1 shows the case where a measurement instrument is placed somewhere in the middle of a SP's network. This architecture can be used as a very simple monitoring mechanism, but when the transport network is composed of multiple sections of circuits, the cause of the end-to-end QoS degradation cannot be located with just one measurement instrument placed in-between.

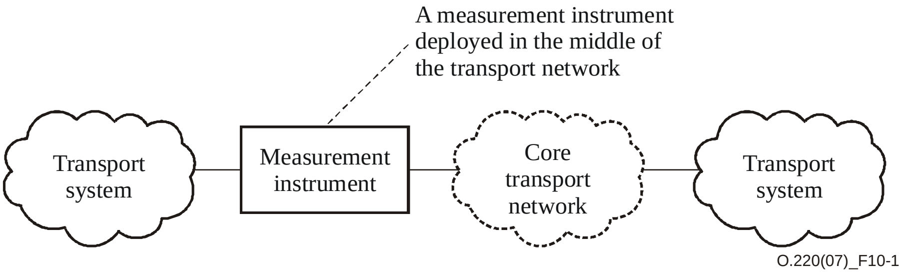

Figure 10-1 – A measurement instrument deployed in the middle of the transport network

Multiple measurement instruments can be deployed in the middle of the SP's transport network, which separates the transport network into several sections for the purpose of fault localization. As shown in Figure 10-2, three measurement instruments are deployed in the middle of the transport network; thus, the SP's network is separated into four sections. When some fault occurs in the SP's network, through the three measurement instruments located in the middle, the fault can be located into one of the sections. The number of measurement instruments that need to be deployed into the network depends on how many sections are required for the fault localization.

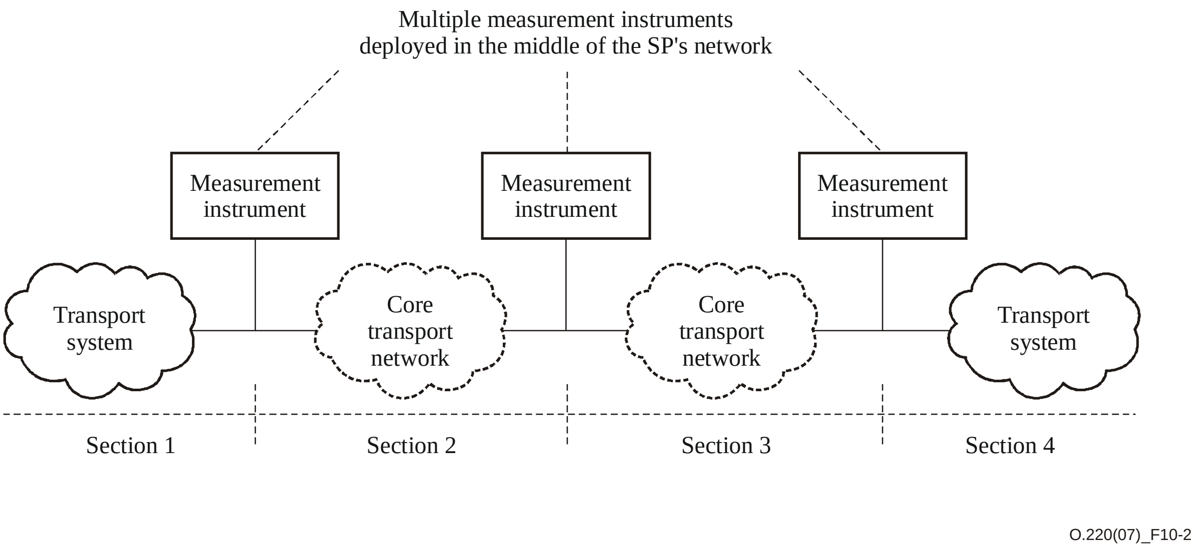

Figure 10-2 – Multiple measurement instruments deployed in the middle of the transport network

10.2 At the edge of the SP's network

Figure 10-3 shows the case where a measurement instrument is placed at the boundary between the SP's network and the SC's network. As a matter of fact, the SP can deploy multiple measurement instruments within its network. If at least two of them are located at the boundaries between the SP's network and the SC's network, it is possible to locate whether a QoS degradation of an LCS is caused by the SP's network or the SC's equipment.

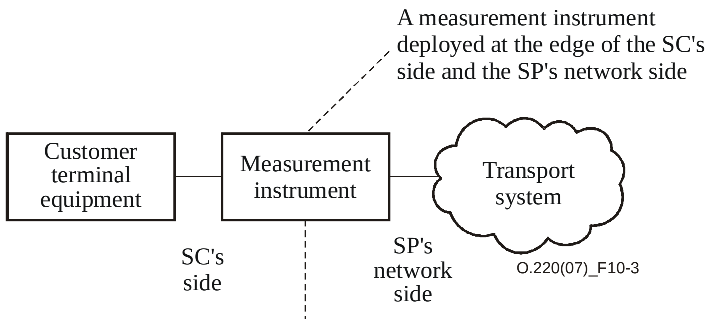

Figure 10-3 – A measurement instrument located at the boundary between the SC's and the SP's network side

11 Connection methods between QoS measurement instruments and management systems

11.1 Measurement instruments connected to TMN OS with individual lines

Figure 11-1 shows the basic connection method between measurement instruments and management systems. Each measurement instrument provides a specific interface to the TMN OSs (that is, it is connected to the DCN with an individual line).

Usually, measurement instruments located at the boundary between the SC's and the SP's networks are far from the TMN OSs which are located at a management centre. Deploying individual lines connecting the remote QoS measurement instruments will introduce more cost for constructing the DCN to collect the measurement results.

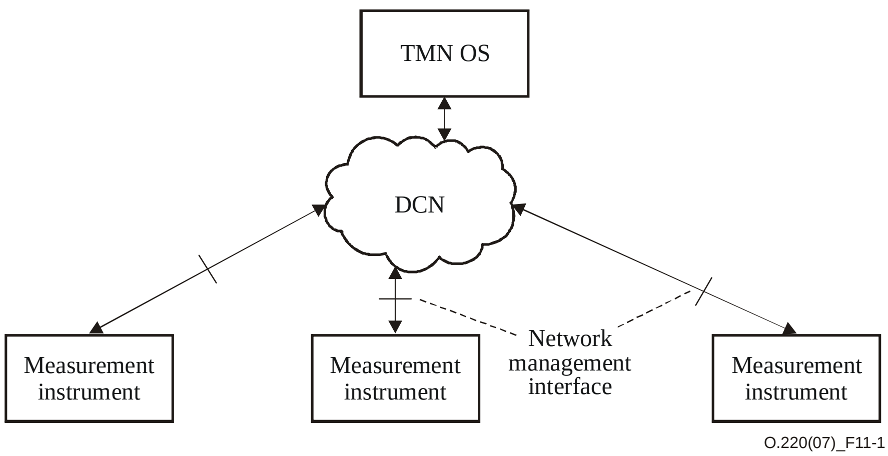

Figure 11-1 – Measurement instruments connected to TMN OS with individual lines

11.2 Measurement instruments connected to TMN OS with a converged management interface

Figure 11-2 shows another connection method between measurement instruments and management systems, where measurement instruments have a converged interface connecting to management systems. In this case, not all the measurement instruments have to provide a direct interface to the TMN OSs. The instruments located at the edge between the SC's and the SP's networks use the transport system being monitored to transfer the measurement results to the next instrument in an in-band way, e.g., using specific measurement frames when the circuit is not busy (as in IP data), or using some reserved bits (such as in a PCM slot). In such a case, it is possible that only the instrument located in the middle of the SP's network provides a management interface to the TMN OSs, and those measurement instruments that are located at the edge between the SC's and the SP's networks transfer the measurement data to TMN OSs through the instrument located in the middle.

In this case, the remote measurement instruments are not physically connected to TMN OSs, instead they use the transport system to convey the measurement results. In this way the cost of constructing the DCN can be greatly reduced, but the measurement instrument will have to provide the capability to change the traffic that is being monitored.

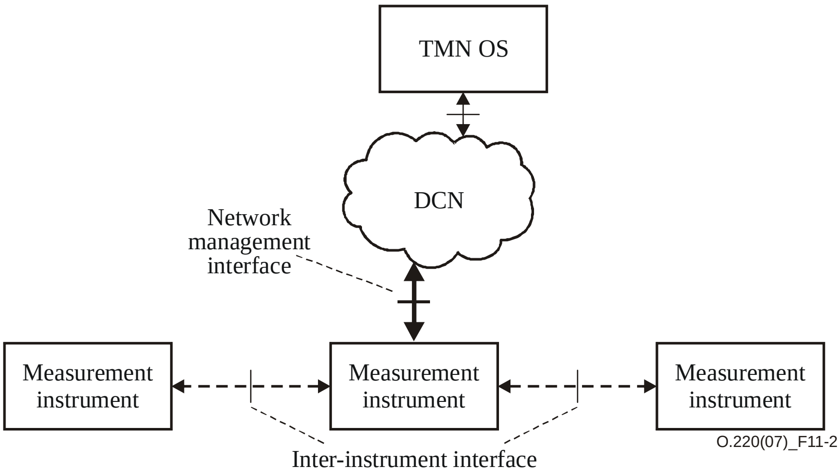

Figure 11-2 – Measurement instruments connected to TMN OS with a converged interface

12 Considerations for selecting the end-to-end QoS monitoring mechanisms using probes

12.1 Reliability consideration

When selecting the connection methods for QoS probes, reliability and deployment features should be considered.

When QoS probes are applied in a transport network, the reliability of the end-to-end transport may also be influenced.

When a QoS probe is parallel-connected to the transport network, it only listens to the circuit, and almost no influence is introduced, which means an unexpected failure of a QoS probe will most probably not have any effect on the transport network itself.

When a QoS probe is serially connected to the network, it receives data from the upstream node as input, processes it (for the QoS monitoring purpose), and then forwards it to the downstream node. During this process, the QoS probe not only "reads" from the circuits, but also "writes" to the circuit (at the output side). The QoS probe can be viewed as a transport node serially connected to the circuits, thus decreasing the reliability of the end-to-end transport service.

12.2 Deployment consideration

There are basically two ways of deploying QoS probes into the transport networks. In the first way, the service is suspended first, then the QoS probes are installed into the network, and the service is restored afterwards. The second case is installing the QoS probes without suspending the provided services.

In the first case, both parallel and serial connection can be used. This can also be done when the network is not providing services yet, and the QoS probes can be installed together with the network elements.

In the second case, the impact on the provided services should be minimal, and only parallel connection for QoS probes can be used for this deployment.

12.3 Interconnection consideration

When all the QoS probes are installed and ready for work, there should be ways to control all the probes and transfer the results for processing. This is done through the management interfaces.

Usually the connection between QoS probes and management systems is through individual lines, which indicates that a specific DCN should be established to interconnect the management system with all the QoS probes that it manages. This physical interconnection architecture is suitable for both parallel and serial connection styles, but it costs more because for each QoS probe located far from the management system, a dedicated line has to be provided for the interconnection purpose.

For the purpose of interconnection, the converged architecture should be considered in order to reduce the cost for DCN construction, but this interconnection architecture is only applicable for the serial connection style of QoS probes.

13 Examples of end-to-end QoS monitoring options

This clause provides two examples of the measurement architectures to meet the requirements of the end-to-end QoS monitoring and supervision. The examples depict two typical combinations of the above three aspects.

13.1 Example 1: Parallel connection with individual management interfaces

Figure 13-1 shows the combination that QoS probes are connected to the transport network circuits to be monitored in parallel, and each QoS probe provides an individual management interface to the TMN OS. In this example, the SP deploys multiple QoS probes within its network, one QoS probe is placed in the middle of the SP's network to collect the samples of QoS parameter values across the line, and two QoS probes are located right at the edge between the SC's side and the SP's network side, so as to locate whether a QoS degradation of an LCS is caused by the SP's network or the SC's internal equipments. In this example, each QoS probe provides a specific management interface to the TMN OSs through the DCN, in order to transfer the collected QoS data.

This example describes the set-up when the LCS is provided by a single SP. If multiple SPs are involved, localization methods like described in clause 10.1 may be used. The means of inter-SP communication of the QoS measurement result is out of the scope of this Recommendation.

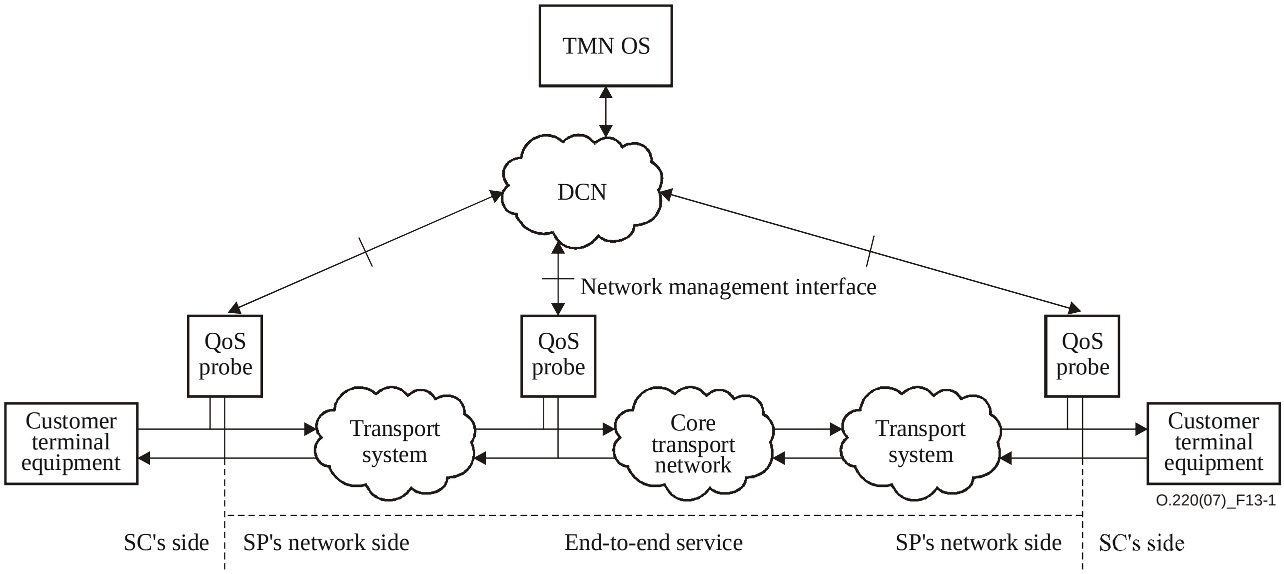

Figure 13-1 – QoS probes parallel-connected to the circuits with individual management interfaces

13.2 Example 2: Serial connection with a converged management interface

Figure 13-2 shows the combination where QoS probes are serially connected to the circuits to be monitored and the QoS probes have a converged interface to the TMN OS. Also in this example, the SP deploys multiple QoS probes within its network, one QoS probe is placed in the middle of the SP's network to collect the samples of QoS parameter values across the line, and two QoS probes are located right at the edge between the SC's side and the SP's network side, so as to locate whether a QoS degradation of an LCS is caused by the SP's network or the SC's internal equipments.

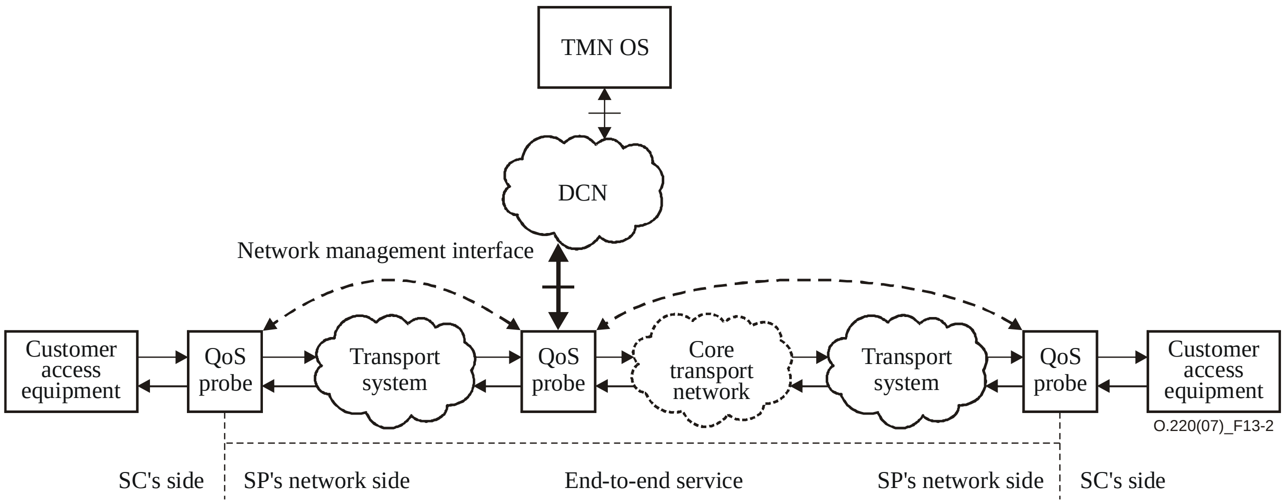

Figure 13-2 – QoS probes serially connected to the circuits with a converged management interface

Appendix I

Examples of alarms and QoS parameters to be monitored

(This appendix does not form an integral part of this Recommendation)

The alarms and QoS parameters to be monitored by a QoS probe may contain (but are not limited to):

– loss of signal (LOS);
– loss of frame (LOF);
– alarm indication signal (AIS);
– errored seconds (ES);
– severely errored seconds (SES);
– unavailable seconds (US).

More QoS parameters can be found in [b-ITU-T E.802], [b-TMF GB917-2] and other related specifications. An application may select its own set of QoS parameters for monitoring based on its precise requirements.

Bibliography

[b-ITU-T E.802] ITU-T Recommendation E.802 (2007), *Framework and methodologies for the determination and application of QoS parameters*.

[b-TMF GB917-2] TMF GB917-2 Version 2.5 (2005), *SLA Management Handbook – Volume 2 – Concepts and Principles*.

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