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SERIES Q: SWITCHING AND SIGNALLING

Testing specifications – Testing specifications for next generation networks

## Framework of Internet related performance measurements

Recommendation ITU-T Q.3960

ITU-T Q-SERIES RECOMMENDATIONS

**SWITCHING AND SIGNALLING**

| | |
|---|---|
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| INTERNATIONAL AUTOMATIC AND SEMI-AUTOMATIC WORKING | Q.4–Q.59 |
| FUNCTIONS AND INFORMATION FLOWS FOR SERVICES IN THE ISDN | Q.60–Q.99 |
| CLAUSES APPLICABLE TO ITU-T STANDARD SYSTEMS | Q.100–Q.119 |
| SPECIFICATIONS OF SIGNALLING SYSTEMS No. 4, 5, 6, R1 AND R2 | Q.120–Q.499 |
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| SPECIFICATIONS OF SIGNALLING SYSTEM No. 7 | Q.700–Q.799 |
| Q3 INTERFACE | Q.800–Q.849 |
| DIGITAL SUBSCRIBER SIGNALLING SYSTEM No. 1 | Q.850–Q.999 |
| PUBLIC LAND MOBILE NETWORK | Q.1000–Q.1099 |
| INTERWORKING WITH SATELLITE MOBILE SYSTEMS | Q.1100–Q.1199 |
| INTELLIGENT NETWORK | Q.1200–Q.1699 |
| SIGNALLING REQUIREMENTS AND PROTOCOLS FOR IMT-2000 | Q.1700–Q.1799 |
| SPECIFICATIONS OF SIGNALLING RELATED TO BEARER INDEPENDENT CALL CONTROL (BICC) | Q.1900–Q.1999 |
| BROADBAND ISDN | Q.2000–Q.2999 |
| SIGNALLING REQUIREMENTS AND PROTOCOLS FOR THE NGN | Q.3000–Q.3709 |
| SIGNALLING REQUIREMENTS AND PROTOCOLS FOR SDN | Q.3710–Q.3899 |
| TESTING SPECIFICATIONS | Q.3900–Q.4099 |
| **Testing specifications for next generation networks** | **Q.3900–Q.3999** |
| Testing specifications for SIP-IMS | Q.4000–Q.4039 |
| Testing specifications for Cloud computing | Q.4040–Q.4059 |

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# Recommendation ITU-T Q.3960

## Framework of Internet related performance measurements


### Summary

Recommendation ITU-T Q.3960 describes a framework for Internet related performance measurements which can be established at the national or international level, providing customers of the existing public telecom networks the possibility to estimate the access related performance.



### History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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### Keywords

Internet, Internet related performance measurement, testing.


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## Table of Contents


| | | Page |
|---|---|---|
| 1 | Scope | 1 |
| 2 | References | 1 |
| 3 | Definitions | 1 |
| | 3.1 Terms defined elsewhere | 1 |
| | 3.2 Terms defined in this Recommendation | 2 |
| 4 | Abbreviations and acronyms | 2 |
| 5 | Conventions | 2 |
| 6 | Measured network sections | 2 |
| 7 | General transparency requirement | 3 |
| 8 | Functional architecture of the measurement system | 3 |
| Appendix I – Test parameters | | 4 |
| Appendix II – Functional architecture of the measurement system | | 5 |
| | II.1 Controller FE | 5 |
| | II.2 Collector FE | 5 |
| | II.3 Measurement agent FE | 5 |
| | II.4 Measurement peer FE | 6 |
| | II.5 Common remarks | 6 |
| | II.6 Security considerations | 6 |
| | II.7 Measurement execution workflow | 6 |
| Appendix III – Example of test execution phases | | 8 |
| Bibliography | | 11 |

## Introduction

The customer's perception of the quality of Internet connection is based on different indicators such as the latency of access to the Internet resource (e.g., time for opening a web page), the bit rate of access to the Internet resource (e.g., the download speed), etc. These and many other indicators characterize the performance of networks and directly influence the experience of customers about the quality of the Internet connection provided by fixed and mobile operators. However, the chain of access to the Internet resources is not only limited by public telecommunication operators but also includes other different agents, since the Internet is a system of computer networks providing worldwide connectivity among users and information sources. Therefore, network operators (fixed and mobile) may advertise a transmission rate associated with the local connection which is not guaranteed between all hosts on the Internet.

For the time being there are many different ways to assess Internet related performance but most of them are based on measurements between a customer and a server that may not belong to public telecommunication operator or Regulator and may be located somewhere in Internet.

This Recommendation describes a test framework for Internet related performance measurements. It was therefore designed targeting the end users of the fixed and mobile networks for the assessment of Internet related performance.

# Recommendation ITU-T Q.3960

## Framework of Internet related performance measurements

### 1 Scope

This Recommendation describes the framework for Internet related performance measurements which can be established at the national or international level, providing customers of the existing public telecommunication operator's networks the possibility to measure the customer's connection to the Internet.

Involved measurement systems, which may also be used for measuring Internet related performance measurements from the customer to a particular Internet resource, should then be based on the functional architecture and the main requirement of the framework provided in this Recommendation.

The location of the particular Internet resource is not defined in this Recommendation being aware of the existence of restricted access to resources in order to conform to national regulations.

### 2 References

The following ITU-T Recommendations and other references contain provisions which, through referenced 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.

None.

### 3 Definitions

#### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 public telecommunication operator (PTO)** [b-ITU-T M.3010]: Is used for conciseness to include telecommunication administrations, recognized operating agencies, private (customer and third party) administrations and/or other organizations that operate or use a Telecommunications Management Network (TMN).

**3.1.2 network operator** [b-ITU-T M.1400]: An operator that manages a telecommunications network. A network operator may be a *service provider* and vice versa. A network operator may or may not provide particular telecommunications services. See clause 1.4.2.3 of [b-ITU-T M.3208.1], and clause 1.4.4 of [b-ITU-T M.3320].

**3.1.3 internet exchange point** [b-Internet Society, "*The Internet Exchange Point Toolkit & Best Practices Guide*"]: A physical location where different IP networks meet to exchange traffic with each other with copper or fiber cables interconnecting their equipment, usually via one or more Ethernet switches. They keep local traffic local.

**3.1.4 functional entity** [b-ITU-T Y.4406]: An entity that comprises a specific set of functions at a given location. Functional entities are logical concepts, while groupings of functional entities are used to describe practical and physical implementations.

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 Internet resource**: Files which are accessible through the Internet.

**3.2.2 measurement system**: Set of hardware and software elements that work/ interact together to achieve the desired measurements.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

FE Functional Entities

HTTP Hypertext Transfer Protocol

HTTPS Hypertext Transfer Protocol Secure

ICT Information and Communications Technology

IEP Internet Exchange Point

IP Internet Protocol

IR Internet Resource

MA Measurement Agent

MP Measurement Peer

RTT Round-Trip Time

SLA Service Level Agreement

TE Terminal Equipment

## 5 Conventions

None.

## 6 Measured network sections

The following two measurements are performed for the estimation of Internet related performance. The first measurement tests the customer's communication path to the Internet (Test Scenario 1). The second one measures the customer's communication path to the particular Internet resource (IR) (Test Scenario 2).

NOTE – Communication path means signalling and media path.

The definitions of each of these measurements are detailed as follows:

– **Operator e2e measurement (Test Scenario 1)**: This measurement should include the whole operator's network (e.g., access, core and backbone networks) from the measurement agent (MA) up to the measurement peer (MP), selected among multiple Internet exchange point (IEP).

– **Server e2e measurement (Test Scenario 2)**: The measurement between customer measurement agent and a relevant Internet resource should include all the network segments from the customer side to the relevant Internet resources beyond the operator network.

It should be noted that test scenario 1 considers network segments under control of the operator. Test scenario 2, on the other hand, comprises the measurement of end-to-end services available in the public Internet which are beyond the control of the operator and would be useful to end users for comparison purposes only.

Figure 1 presents both test scenarios where the unified measurement methodology is to be applied. For test scenario 1, the measurement peer has been chosen close to the IEP:

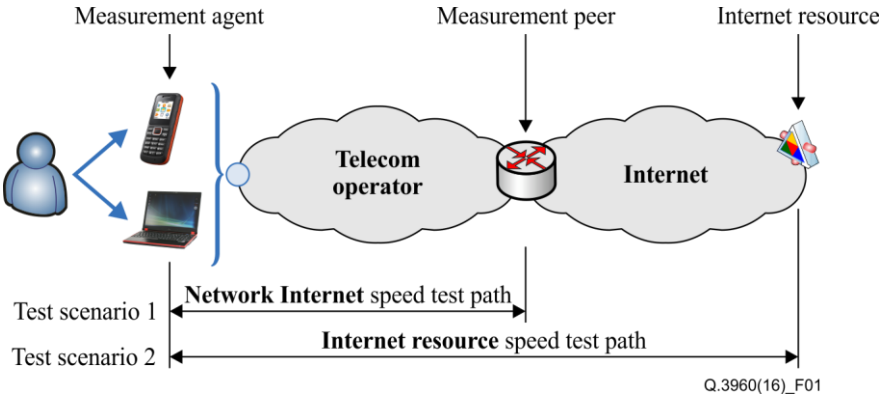


**Figure 1 – Global scenario and test definition**

## 7 General transparency requirement

Any measurement system developed under this framework shall be based on an open approach which all information and communications technology (ICT) players (e.g., regulator, operator, customer, etc.) can rely on. Transparency and comparability are pursued by ensuring publicly available measurement tools for end users and comprehensively defined measurement methodologies including configuration parameters, test conditions, metrics and results processing algorithms.

NOTE 1 – The measurement methodologies are the subject of different ITU-T Recommendations.

NOTE 2 – With "transparency" it is intended that all test parameters and methods of assessment are openly documented, to a degree where the measurements can be repeated by third parties.

## 8 Functional architecture of the measurement system

The measurement system should be composed of functional entities (FE).

NOTE – The functional architecture shown in the appendix does not impose any particular implementation constraints and different FEs can be mapped to one or many software/hardware nodes (considering other architectures like the one provided by IETF in [b-IETF RFC 7594]).

# Appendix I

## Test parameters

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

This appendix describes considerations relevant for the designation of the test parameters to be measured.

At least the following parameters should be measured from/to the specific measurement peers by the proposed methodology (for both test scenarios):

- **Download data transmission speed**

  The data transmission speed achieved in the downlink between the measurement agent and the correspondent measurement peer.

- **Upload data transmission speed**

  The data transmission speed achieved in the uplink between the measurement agent and the correspondent measurement peer.

- **Two-way delay**

  Also defined as the round-trip time (RTT) delay, the two-way delay is twice "the time required for a packet to traverse the network or a segment of the network" [b-IETF RFC 2681].

NOTE – The test parameters and specific metrics will be specified in a separate ITU-T Recommendation.

# Appendix II

## Functional architecture of the measurement system

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

Figure II.1 shows the functional architecture of the basic measurement system.

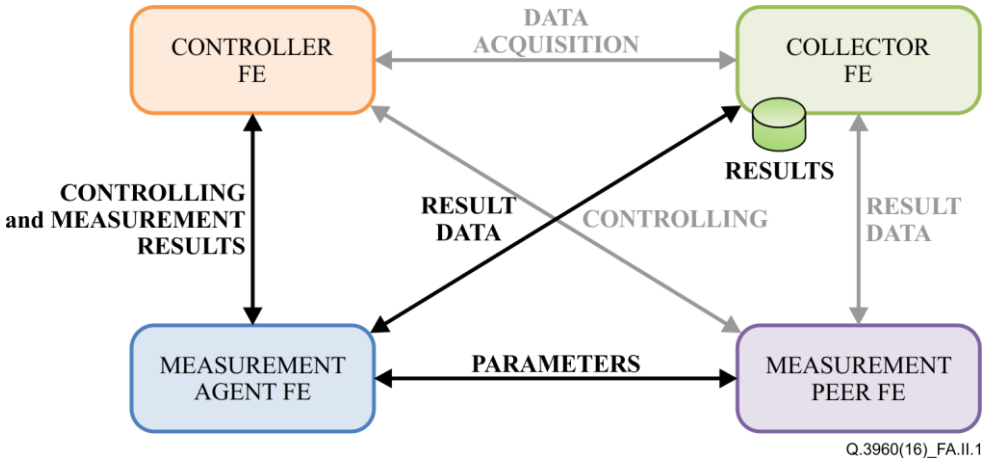


**Figure II.1 – The functional architecture of the basic measurement system**

### II.1 Controller FE

The controller is a FE that is able to control the testing mechanisms on a particular MA. The controller should allow the specification of test scripts defining the measurement workflow (i.e., different stages and testing procedures involved) to later trigger the execution of the relevant test scenarios on that particular MA. The specification process may demand the acquisition of existing data from the collector.

Furthermore, the controller provides the user with the measurement environment and tools to execute the test throughout a web page or a hypertext transfer protocol/secure (HTTP/s) access. It should be capable of hosting and serving the required scripts and contents to be used during the test. Additionally it will provide users with an interface to access measurement results.

### II.2 Collector FE

The collector is a FE that gathers, processes and stores measurement results and other statistical data from all measurement agents connected to the controller and from the measurement peers in case they are specifically deployed for the specific test scenario. It should be capable of handling properly secured transmission of data.

### II.3 Measurement agent FE

The measurement agent is a FE that has the functionality to execute the test scripts defined in the controller, obtain the test results and upload the relevant result data to the collector.

The measurement agent may well admit two different configurations.

Option a) involves a terminal equipment (TE), including but not limited to computer, smartphone, tablet, etc.) physically controlled and generally owned by the user.

– This terminal equipment should have an active Internet connection and a web-browser in order to access the web-site hosted at the controller, or an app to access the test in case of a portable device.

– The TE should also be capable of establishing secure communications to the collector, for the safe transfer of results and other statistical data.

Option b) involves the same TE and the existence of a MA in the form of a middlebox (probe) or additional hardware integrated in the TE.

– The local measurement peer also requires any hardware and software that enables the remote management and configuration of the device without requiring any specific operation from the customer.

NOTE – In order to provide a meaningful result for benchmarking in test scenario 1, the measurement agent and measurement peers should be directly connected to the network operator so that no network sections out of the control of the operator are considered in the measurement. That would include home sections not under the control of the operator (typically shared Wi-Fi connection with no operator service level agreement (SLA) in place).

### II.4 Measurement peer FE

The measurement peer is a FE which is able to respond on testing messages sent from MA and possibly collect measurement data to be uploaded to the collector. Additionally, it may provide resource usage monitoring capabilities so that the controller could schedule tests to prevent any foreseeing interference impacting tests results.

### II.5 Common remarks

All the functional entities should ensure that no interference among concurrent activities is affecting the test result by proper dimensioning in terms of HW/SW and link capacity. Furthermore, the recipient of the result should be notified of the conditions required to ensure a reliable measurement and the possible measurement errors due to the unfulfillment of such conditions (including but not limited to cross traffic, background applications, OS and applications configuration, etc.).

### II.6 Security considerations

The implementation of this functional measurement architecture has to follow national privacy and security requirements.

NOTE – Tests may raise different security and confidentiality concerns about the data collected either from the TE and/or the MA (including but not limited to user identity, location, Internet protocol (IP) address, etc.). Specific measures to secure every data transfer, authenticate different FEs and anonymize specific collected data are described in [b-IETF RFC 7594]. In any case, adopted security and privacy threat mitigations may have to be deployed according to every national regulation.

### II.7 Measurement execution workflow

The workflow/execution/implementation/procedure of the measurement system is shown in Figure II.2.

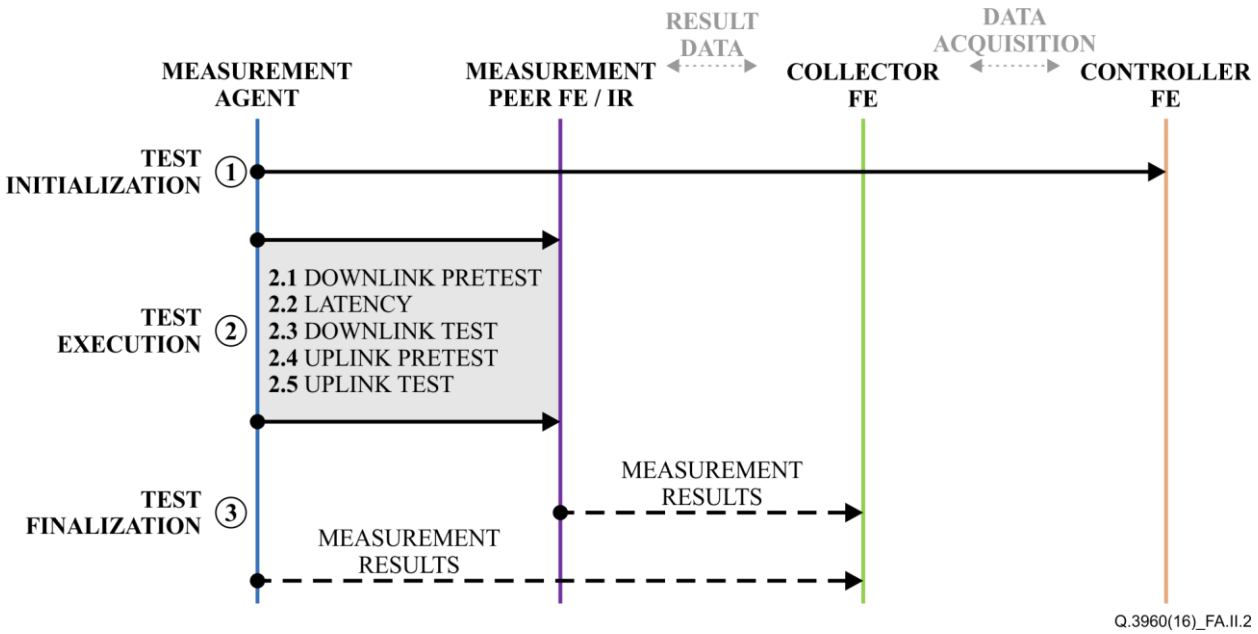


**Figure II.2 – The workflow of the measurement system**

**Step 1: Initialization** – Client access the controller and, after establishing a proper connection, client and server exchange the information required for running the test. The test script may be uploaded from the controller to the particular measurement agent (being that a TE or measurement equipment – middlebox).

**Step 2: Execution** – Once the test script is accessed in the MA it should be executed towards selected measurement peers depending on the specific test scenario. Even though the test methodologies to be used at this step will be specified in separate ITU-T Recommendations, some examples are described in Appendix III.

**Step 3: Finalization** – After finishing all tests, the MA (and possibly the MP) sends the collected data to the collector, that later checks the integrity and usability of the result. All tests, successful or unsuccessful, are stored by the collector. When end users have access to the measurement test, hardware and software information from their measurement agent should be collected for better statistical results evaluation. Collecting data on the TE hardware and software configuration (i.e., operating system, browser) can be useful not only for statistical result evaluation but also to send warnings to the users about unsuitable configuration if detected or other configuration problems that may lead to unreliable measurements. In contrast, collecting user's information can be a sensitive issue since it could threaten the privacy of the user if some delicate information is collected (i.e., user identity). The information that can be collected and the mechanism to protect privacy or any other possible security constraints to be applied will depend on each national regulation.

Additionally, enhanced functionalities could be offered to the clients with the aim of collecting further information. For instance, the option of user's registration could also be available to facilitate users sharing and comparing their results and to access the historical data of their measurements. User's registration will also help to collect general information for statistical data analysis (region and country averages, ISPs results information, etc.). Nevertheless, registration should not be mandatory.

The controller should have the possibility to display all measurement results at the dedicated web page, providing access to all authorized customers. If using the controller for the outcome results comparison or reports presentation, via the web interface, an additional communication path could be implemented between controller and collector for data acquisition. Customer should have access to the measurement results from his equipment (e.g., PC, smartphone, etc.) throughout a web page or an application (i.e., smartphone app) connected to a controller.

# Appendix III

## Example of test execution phases

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

The test methodologies for the execution phase of the proposed measurement procedure will be specified in a separate ITU-T Recommendation. Nevertheless, some examples are described in this appendix.

- Step 2.1: Downlink pre-test

  The downlink pre-test serves to evaluate and establish parameters for downlink subtest. In order to do so it may carry out a series of subtests to evaluate the most suitable configuration parameters (Figure III.1).

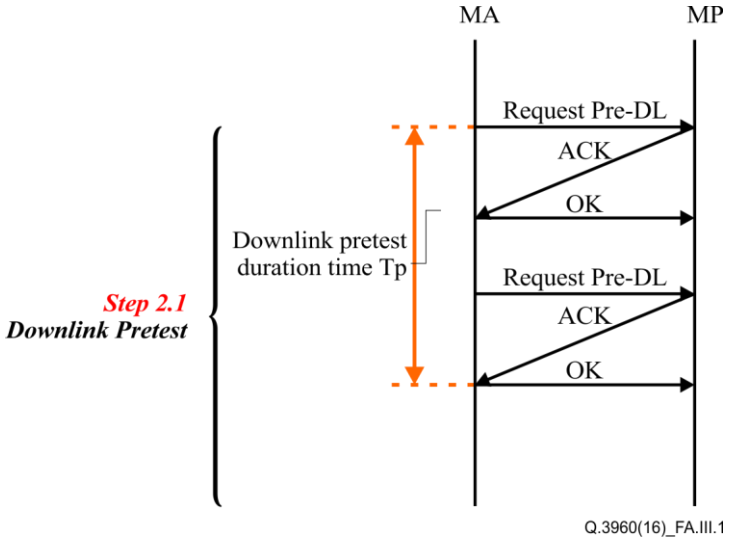


**Figure III.1 – Example of downlink pre-test**

- Step 2.2: Latency test

  During this phase, the client sends p "pings" [b-IETF RFC 2925] in short intervals to the measurement peer to test the latency of the connection (Figure III.2).

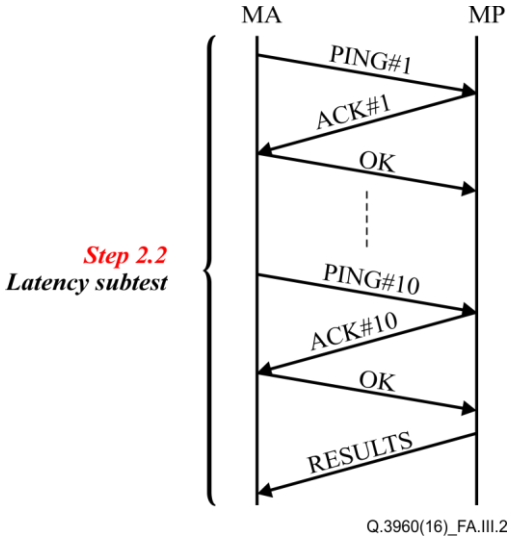


**Figure III.2 – Example of latency test**

- Step 2.3: Downlink test

  During this phase, the achieved data transmission speed in the downlink between the measurement agent and the correspondent measurement peer will be measured (Figure III.3). The parameters computed in Step 2.1 are used to ensure the reliability of the actual measurement.

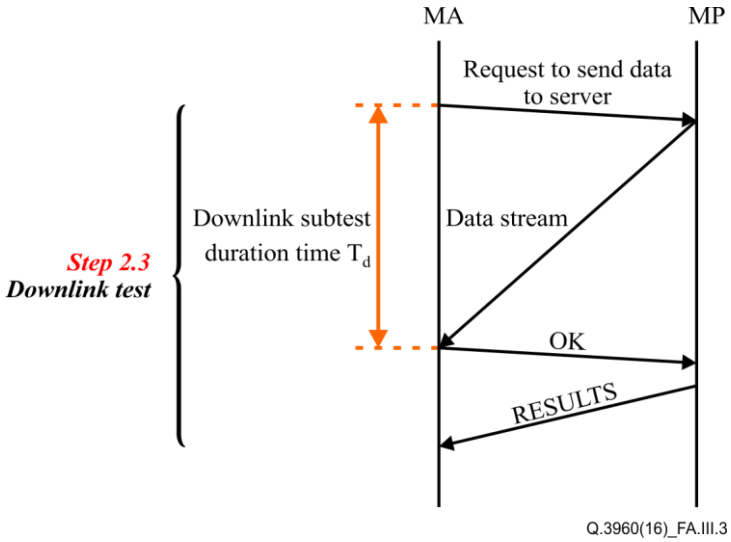


**Figure III.3 – Example of downlink test**

- Step 2.4: Uplink pre-test

  The uplink pre-test intends to evaluate and establish parameters for uplink subtest (Figure III.4). Similar to the downlink phase, this step aims at inferring the most suitable uplink test related parameters to ensure proper final measurement and may involve one or more iterations/sub tests.

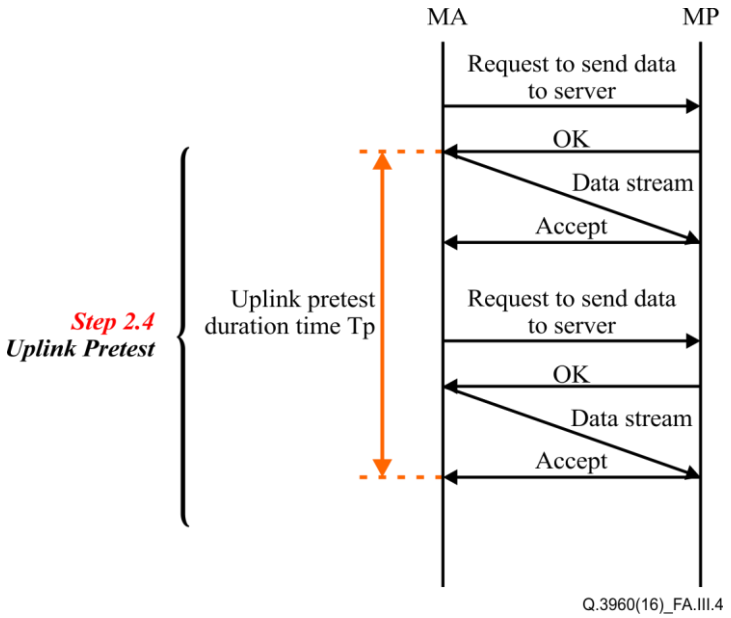


**Figure III.4 – Example of uplink pre-test**

- Step 2.5: Uplink test

  During this phase, the achieved data transmission speed in the uplink between the measurement agent and the correspondent measurement peer will be measured (Figure III.5).

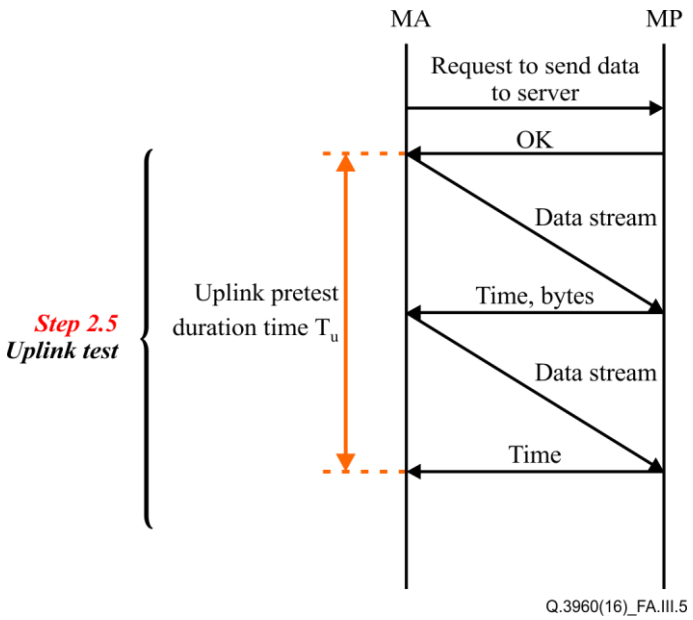


**Figure III.5 – Example of uplink test**

# Bibliography


[b-ITU-T M.1400] Recommendation ITU-T M.1400 (2015), *Designations for interconnections among operators' networks*.

[b-ITU-T M.3010] Recommendation ITU-T M.3010 (2000), *Principles for a telecommunications management network*.

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

[b-ITU-T M.3320] Recommendation ITU-T M.3320 (1997), *Management requirements framework for the TMN X-Interface*.

[b-ITU-T Y.4406] Recommendation ITU-T Y.4406/Y.2016 (2009), *Functional requirements and architecture of the NGN for applications and services using tag-based identification*.

[b-ETSI TS 103 222-1] ETSI Technical Specification 103 222-1 (2015), *Speech and multimedia Transmission Quality (STQ); Reference benchmarking, background traffic profiles and KPIs; Part 1: Reference benchmarking, background traffic profiles and KPIs for VoIP and FoIP in fixed networks*.

[b-IETF RFC 2330] IETF RFC 2330 (1998), *Framework for IP Performance Metrics*. https://tools.ietf.org/html/rfc2330

[b-IETF RFC 2680] IETF RFC 2680 (1999), *A One-way Packet Loss Metric for IPPM*. https://tools.ietf.org/html/rfc2680

[b-IETF RFC 2681] IETF RFC 2681 (1999), *A Round Trip Delay Metric for IPPM*. https://tools.ietf.org/html/rfc2681

[b-IETF RFC 2925] IETF RFC 2925 (2000), *Definitions of Managed Objects for Remote Ping, Traceroute, and Lookup Operations*. https://tools.ietf.org/html/rfc2925

[b-IETF RFC 3148] IETF RFC 3148 (2001), *A Framework for Defining Empirical Bulk Transfer Capacity Metrics*. https://tools.ietf.org/html/rfc3148

[b-IETF RFC 3393] IETF RFC 3393 (2002), *IP Packet Delay Variation Metric for IP Performance Metrics (IPPM)*. https://tools.ietf.org/html/rfc3393

[b-IETF RFC 4656] IETF RFC 4656 (2006), *A One-way Active Measurement Protocol (OWAMP)*. https://tools.ietf.org/html/rfc4656

[b-IETF RFC 5012] IETF RFC 5012 (2008), *Requirements for Emergency Context Resolution with Internet Technologies*. https://tools.ietf.org/html/rfc5012

[b-IETF RFC 5357] IETF RFC 5357 (2006), *A Two-Way Active Measurement Protocol (TWAMP)*. https://tools.ietf.org/html/rfc5357

[b-IETF RFC 5881] IETF RFC 5881 (2010), Bidirectional *Forwarding Detection (BFD) for IPv4 and IPv6 (Single Hop)*. https://tools.ietf.org/html/rfc5881

[b-IETF RFC 6349] IETF RFC 6349 (2011), *Framework for TCP Throughput Testing*. https://tools.ietf.org/html/rfc6349

[b-IETF RFC 7398] IETF RFC 7398 (2015), *A Reference Path and Measurement Points for Large-Scale Measurement of Broadband Performance*. https://tools.ietf.org/html/rfc7398

[b-IETF RFC 7594] IETF RFC 7594 (2015), *A Framework for Large-Scale Measurement of Broadband Performance (LMAP)*. https://tools.ietf.org/html/rfc7594

[b-IETF RFC 7536] IETF RFC 7536 (2015), *Large-Scale Broadband Measurement Use Cases*. https://tools.ietf.org/html/rfc7536

[b-IETF lmap-model] *Information Model for Large-Scale Measurement Platforms (LMAP)* (2015), Draft-ietf-lmap-information-model-07 https://tools.ietf.org/id/draft-ietf-lmap-information-model-07.html

[b-IETF metric-reg] *Registry for Performance Metrics* (2015), Draft-ietf-ippm-metric-registry-05 https://tools.ietf.org/html/draft-ietf-ippm-metric-registry-05

[b-Internet Society] Internet Society (2014), *The Internet Exchange Point Toolkit & Best Practices Guide*.

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