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**Notes**

This document contains the comments on the Consented version of Q. 3960 (formerly Q.FW_Int_sp_test) agreed at the SG 12 meeting as described above.

**Contact:** A.C. Morton, Vice-Chairman and Rapp. Q17
AT&T
USA

Tel: +1 732 420 1571
Fax:
Email: acmorton@att.com

INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T Series Q

STANDARDIZATION SECTOR (mm/yyyy)

SERIES ~~Q: SWITCHING AND SIGNALLING~~[ACM1]

## Recommendation ITU Q.FW_Int_sp_test

## Framework of Internet speed measurements for the fixed and mobile networks

**Content**

## 1. Motivation

The customer's estimation of the quality of Internet access is based on the different parameters 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. ~~All t~~These and many other parameters [Y.1540] characterize the performance of networks and directly influence the opinion 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 limited by telecom operators and includes also internet service providers, content service providers, because the Internet is a system of computer networks providing worldwide connectivity among users and information sources~~ete~~. ~~Moreover,~~ ~~t~~Telecom operators (fixed and mobile) may advertise ~~the Internet~~a speed associated with the local connection which ~~in the most cases~~ is not guaranteed between all hosts on the Internet. ~~As a result of all above facts customers are disappointed.~~[ACM2]

In this regard, the development of unified approach to measure the access speed to the Internet as well as an access speed to the Internet resources can become one of the most important issues for all ICT players (e.g. operators, regulators, Internet community, etc.) and especially for customers.

For the time being there are many different ways to assess the rate of Internet speed but most of them are based on the estimation of speed between a customer and a server which belongs not to telecom operator or Regulator and located somewhere in Internet, in most cases outside of the customer's country (e.g. speedtest.net, netztest.at, velocimetro.org, etc.). Also, there are currently no standardized metrics for Internet speed in the Recommendations of the ITU-T, and this topic is under study.

This Recommendation describes test framework for Internet speed measurement, it was therefore designed targeting the end users of the fixed and mobile networks for the assessment of the Internet speed connection. Also it may be used by Regulators/Operators for the assessment of the Internet speed connection at the national level.

The proposed framework has been developed on the basis of other standards trying to comply with any existing regulation.

### 1.1. Disadvantages of the existing methods of data speed measurement

The existing Internet speed measurement systems which are made publically available in the Internet have several issues which do not allow customers to get the reliable measurement results ~~and operators to use it as a part of Service Level Agreement (SLA)~~[ACM3]. Beyond the lack of standardized metrics for Internet speed in the Recommendations of the ITU-T, t~~T~~here are the following issues:

- the obtained test results, which were achieved by one testing method, may vary from results achieved by other one. Obviously, the testing results depend on the amount of the network segments which were used during a peer-to-peer testing (not guarantee that a peer-to-peer connection is based on telecom operator's network only and does not include other Internet segments);
- the results of measurements might be impacted to one or more of the following factors:
  - overload of the measured server and its capabilities;
  - hardware configuration and performance of the customer's equipment;
  - the installed software (e.g. operating system, applications, etc.) and/or available performance of the user's terminal at the time of measurement;
  - network performance (e.g. busy hour) and the level of utilization of customer's interface connected to the Internet at the time of measurement;
  - activated security software and hardware (e.g. firewalls, anti-virus, etc.) at the time of measurement;

  - differentiated treatment due to recognizing the measurement flows to increase the performance experienced;
  - private network performance between the end-user and the service interface may reduce the overall performance measured (operator and user networks combined);
  - there are many more factors, including DNS connectivity, DoS attack on the tested path, routing (interior and exterior), issues with MTU size and resulting fragmention.
- end-users may generate traffic during a measurement and negatively influence the measurement result, and this may take place without the knowledge of the measuring user as it may be from background applications or other authorized users on the same connection.
- for increasing accuracy some of the existing methods perform the set of random testing attempts at the different time, but the testing schedule does not take into account the busy hour;
- some test methods drop around 40% of the measurement results, which does not allow ICT players to get a reliable result.

**Keywords**

Internet, testing, measurement of QoS, network performance, QoE

## 2. Scope

This Recommendation describes the framework of Internet speed quality measurement which can be established at the national or international level, providing customers of the existing telecom operator's networks the possibility to estimate the access speed to the Internet ~~and to the Internet resources~~[ACM4].

This Recommendation describes test framework for Internet speed measurement, it was therefore designed targeting the end users of the fixed and mobile networks for the assessment of the Internet speed connection. ~~Also it may be used by Regulators/Operators for the assessment of the Internet speed connection at the national level.~~ [ACM5]~~The framework will support providing transparent, trust-based measurement results which can be used by all ICT players (e.g. user, regulator, operator, ISP, etc.).~~[ACM6]

The recommendation provides the architecture of the measurement framework, ~~measurement parameters and measurement procedure~~[ACM7] which should be used on the fixed and mobile operators to estimate the access speed to the Internet resources.

The requirements for the measurement algorithm are a subject of a separate ITU-T Recommendation.

## 3. References

[ETSI EG 202 057-4] ETSI Guide 202 057-4 (2008), *Speech processing, transmission and Quality aspects (STQ); User related QoS parameter definitions and measurements; Part 4. V1.2.1.*

[ETSI TS 103 222-1] ETSI Technical Specification 103 222-1 (2015), *Speech and multimedia Transmission Quality (STQ); 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.*

[ETSI EG 202 009-2] ETSI Guide 202 009-2 (2014), *Quality of telecom services; Part 2: User related indicators on a service specific basis*.

[ITU-T Y.1541] Recommendation ITU-T Y.1541 (2011), *Network performance objectives for IP-based services*.

~~[ITU-T G.1050] Recommendation ITU-T G.1050 (2011), *Network model for evaluating multimedia transmission performance over Internet Protocol*.~~[ACM8]

[IETF RFC 2681] IETF RFC 2681 (1999), *A Round Trip Delay Metric for IPPM*.

[BBF TR-304] BBF Technical Report 304 (2015), *Broadband Access Service Attributes and Performance Metrics*.

## 4. Definitions

*Data Transmission Speed*: the data transmission rate that is achieved separately for downloading and uploading specified test files between a remote web site and a user's computer.

*Internet Service Provider (ISP)*: organization that provides users with an Internet access.

*Telecom operator*: an organization responsible for identification and management of telecommunication network used wholly or partly for the provision of publicly available telecommunication services.[ACM9]

*Internet Exchange Point*: is a key locale for interconnection and exchange of traffic – technical facilities where all Internet players interconnect directly with each other. (World Telecommunication/ICT Policy Forum Geneva, Switzerland, 14-16 May 2013, backgrounder-wtpf-13-ixps-en.htm)

## 5. Abbreviations

BDP Bandwidth-Delay Product
CDN Content Data Network
IR Internet Resource
ISP Internet Service Providers
MA Measurement Agent
MP Measurement Peer
RTT Round-Trip Time
SLA Service Level Agreement

## 6. Conventions

None

## 7. Measurement tests definition

Two different types of measurement tests are proposed for the estimation of Internet speed quality. The first one considers the operator network itself. The second one considers the whole access speed to the Internet resource, since this measurement may be closer to the Internet speed quality as perceived by user.

The definitions of each of these measurements are next detailed:

– **Network Internet speed test:**
This test will measure the absolute value of the end-to-end data transmission speed (bit rate) between customer Measurement Agent (MA) and an external interface of exchange point (peering point) ("**A**" in figure 1). This measurement should include the whole operator's network (access, transport, service control segments) up to the exchange point (peering point)

and should be measured on the output of an specific exchange point interface (i.e. the exchange point with the highest data volume exchange used by operator).

– **The Internet resource speed test**[ACM10]**:**

The test will measure the absolute value of the end-to-end data transmission speed (bit rate) amongst customer Measurement Agent (MA) and a relevant Internet resource ("**B**" in figure 1). This measurement should include the whole network from the customer side to the relevant Internet resource[ACM11].

The measurement could be based on ~~algorithms~~[ACM12]protocols of the TCP/IP stack and should be adaptable to the technologies that are used on the Measurement Agent.

Figure 1 presents the global scenario where the unified measurement methodology is to be applied:

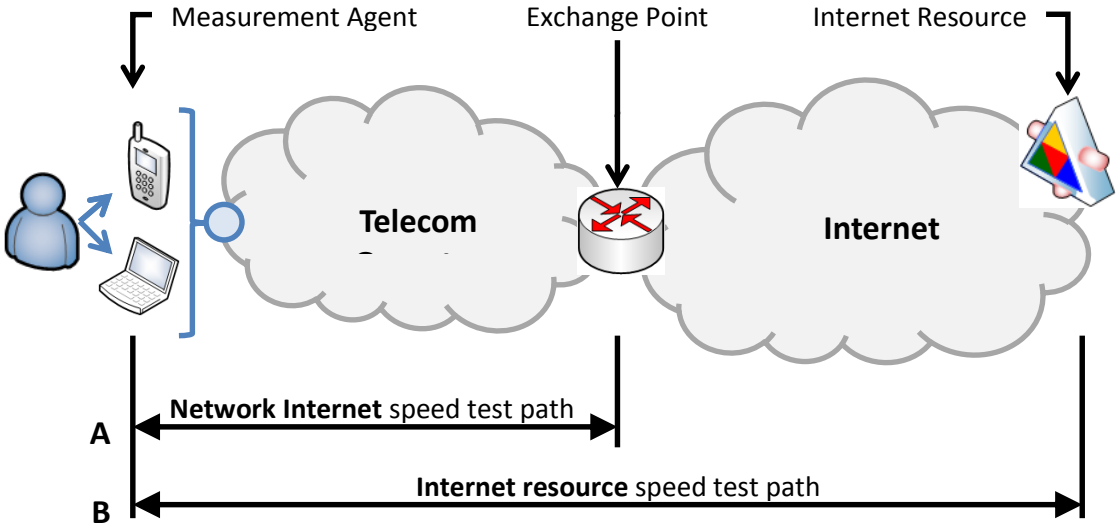


Figure 1. Global scenario and test definition[ACM13]

## 8. Basic concept

The concept of the measurement system should be based on the transparent approach which all ICT players (e.g. regulator, operator, ISP, customer, etc.) can rely on.

In general, both the Network Internet speed test and the Internet resource speed test should meet the following general ~~requirements~~goals[ACM14]:

- transparency [ACM15]and validity;
- accuracy;
- repeatability, ~~consistency with the protocols and used interfaces on Measurement Agent;~~[ACM16]
- natural conjugation with the assessment of the quality of telecommunications services in general;
- accessibility to stakeholders (users, user's terminal Internet service providers, network operators, ISPs, regulators).

There are two possible options regarding the location of the measurement system[ACM17]:

- outside operator's facilities (independent premises) with direct (loss-less) connectivity to service interfaces;
- on the existing operator's networks.

The measurement system might be implemented at the national and/or international level, providing access to the particular measurement results to ICT players whether they connected.[ACM18]

~~The implementation on the international level is a preferred solution for the assessment of the Internet resource speed, due to the following reasons:~~

- ~~accuracy of measurements – all measurements will be conducted from one Internationally recognized physical entity connected to the Internet;~~
- ~~comprehensive analyses of user´s hardware and software – a centralized possibility to inform customers about unsuitable configuration if detected or other configuration problems that may lead to unreliable measurements (see Annex A);~~
- ~~global visualization of measured results – customers can compare "tariff/offer" advertised by telecom operators;~~
- ~~differentiated tariffs for OTT services – a possibility to set up tariffs for OTT services provided on the fixed and mobile networks.~~[ACM19]

In spite of the location, all involved ICT players must have the comprehensive access to the features of the measurement system in accordance with their rights. At least each of them has to get access to the measurement data.

## 9. Test Facilities

The measurement system (Figure 2) should be composed of the following components:

Controller — is a tool (software/hardware) which is able to control testing procedures on a particular Measurement Agent (MA). The Controller should allow uploading test scripts on any MA and start executing the relevant test scenarios on the particular Measurement Agent.

Collector — is a tool (software/hardware) which collects measurement data from all Measurement Agents connected to the Controller.[ACM20]

Measurement Agent — is a tool (software/hardware) which has functionality to execute test scripts uploaded from Controller.

Measurement Peer – is a tool (software/hardware) which is able to respond on testing messages sent from MA.

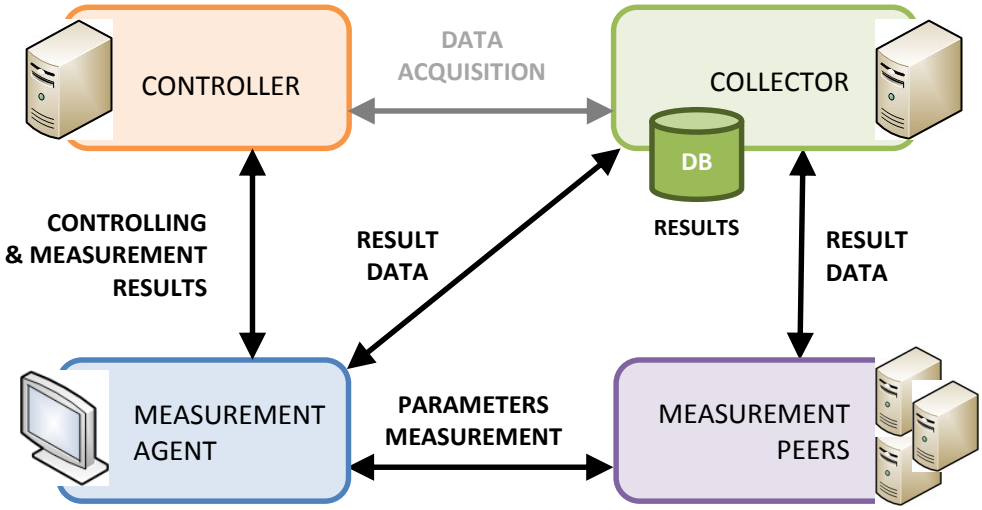


**Figure 2.** The architecture of the basic measurement system

### 9.1 Controller requirements[ACM21]

The Controller provides the user with the measurement environment and tools to execute the test throughout a web page or a HTTP/s access. Therefore, the next requirements must be considered:

- It must be capable of hosting and serving the required scripts and contents to be used during the test. Ports 80 and/or 443 should be open for this matter.
- It can coexist with the Collector within the same device. In that case, the Collector requirements also apply to this server.
- It must not coexist with a Measurement Peer (MP) within the same device in order not to interfere with the test itself. Measurement Peers are already high requirement devices.

### 9.2 Collector requirements[ACM22]

This facility shares many of the requirements with the Controller:

- It must not coexist with a Measurement Peer within the same equipment in order not to interfere with the test itself.

As well as some additional features:

- The server should be capable of handling ciphered transmissions of data.
- It must be capable of handling, processing and storing results and other statistical data.

### 9.3 Measurement Agent requirements[ACM23]

The Measurement Agent may well admit two different configurations.

Option a) involves a Customer Equipment (CE) only (computer, smartphone, tablet, etc.) physically controlled and generally owned by the user.

- This customer equipment has no specific requirements other than having an active internet connection and a browser in order to access the site hosted at the Controller, or a preinstalled app to access the test in case of being a portable device.
- The customer equipment should be also capable of establishing ciphered communications ~~with any of the other equipment of the facilities, and especially with~~[ACM24] the Collector, for the safe transfer of results and other statistical data.

Option b) involves the same Customer Equipment (CE) and the existence of a Measurement Agent (MA) in the form of a middlebox (probe) or additional hardware integrated in the CE[ACM25].

- The same customer equipment requirements are applicable to the local Measurement Peer in the form of a middlebox or additional attached hardware.
- 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.

### 9.4 Measurement Peers requirements

The Measurement Peers are the most demanding facilities in terms of network conditions. Each device has this requirement:

- It requires proper dimensioning in terms of HW/SW and link capacity to take into account interference amongst concurrent tests. Additionally, it must provide resource usage monitoring

capabilities so that the Controller could schedule tests as to prevent any foreseeing interference impacting tests results.

## 10. Architecture of the measurement system

The architecture of the measurement system should provide a possibility to conduct two types of measurements referred in clause 7. The Figure 3 presents a general architecture of the measurement system.

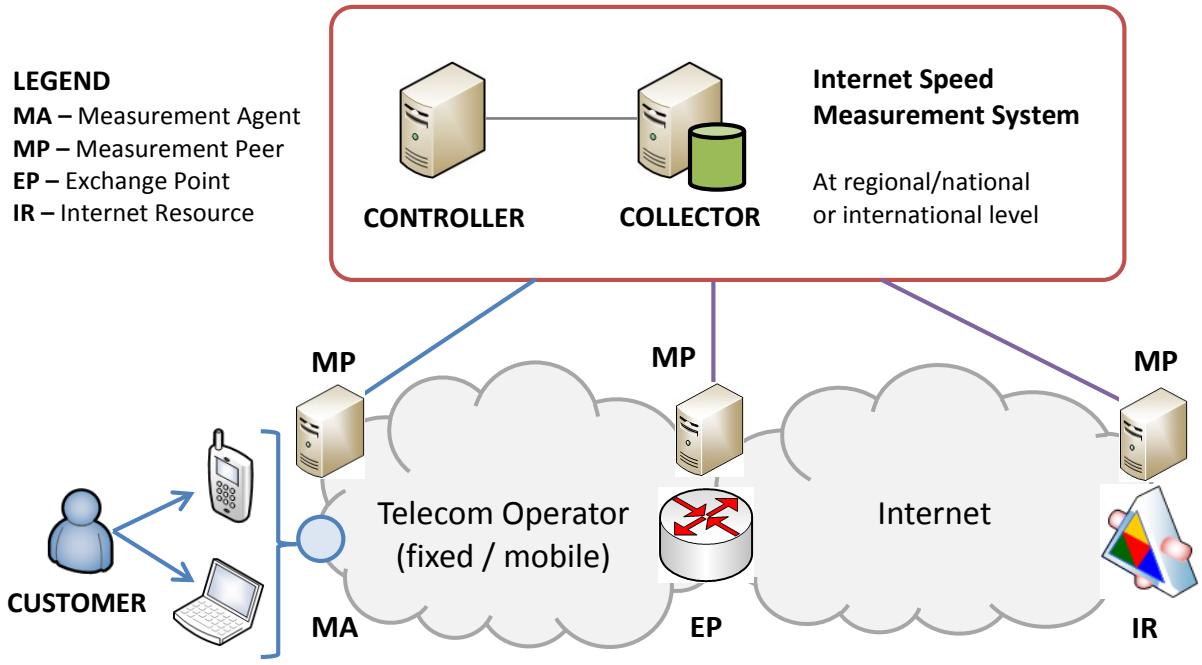


**Figure 3**. The general architecture of the Internet speed measurement system

Due to two types of measurements referred in section 7, there are two possible options for the location of the Measurement Peers on the exchange point and Internet resource sides.

First option is devoted to measurements of the Internet access speed. The Measurement Peer should be placed on the output of the exchange point interface (peering point) that connects the operator to the rest of the Internet.[ACM26] In case of limitations in connection Measurement Peer on the output interface of the Exchange Point (EP) interface, operator is allowed to locate Measurement Peer within the operator network, as close to the internal interface of the exchange point, assuring guaranteed bandwidth on this direction.[ACM27]

Figure 4 defines the location of the Measurement Peer (MP) for the Network Internet speed test:[ACM28]

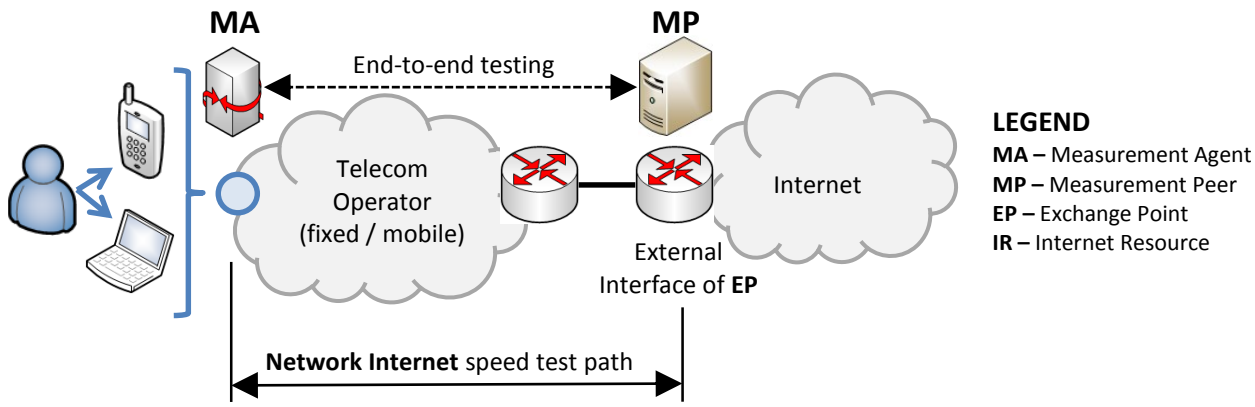


Figure 4. Measurement Peer location for the Network Internet speed test

Second option is devoted to measurements of the Internet resource speed. Figure 5 defines the location of the Measurement Peer for the Internet resource speed test:

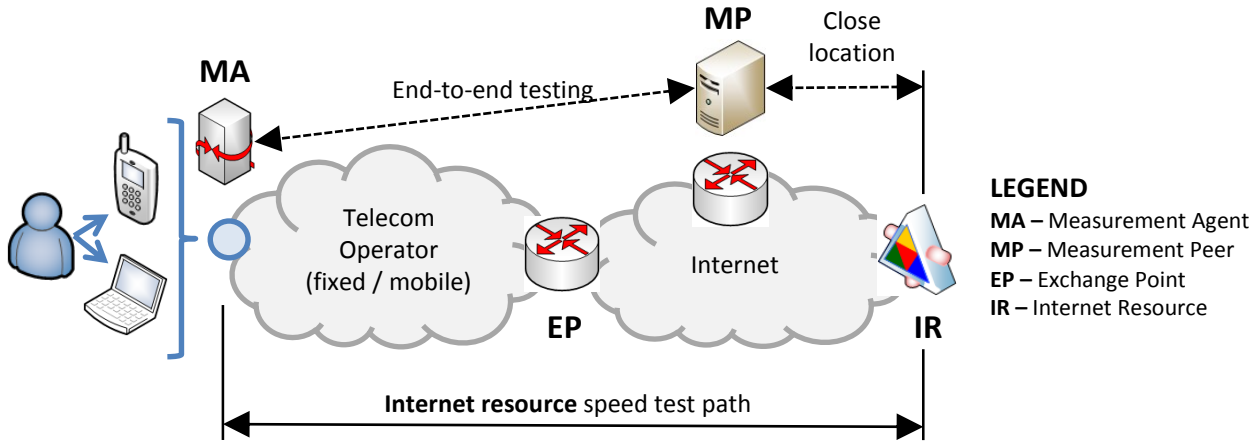


Figure 5. Measurement Peer location for the Internet resource speed test

The detailed Internet resource related tests will be specified in a separate ITU-T Recommendation.[ACM29]

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## 11. Workflow

The workflow of the measurement system is shown on figure 6.

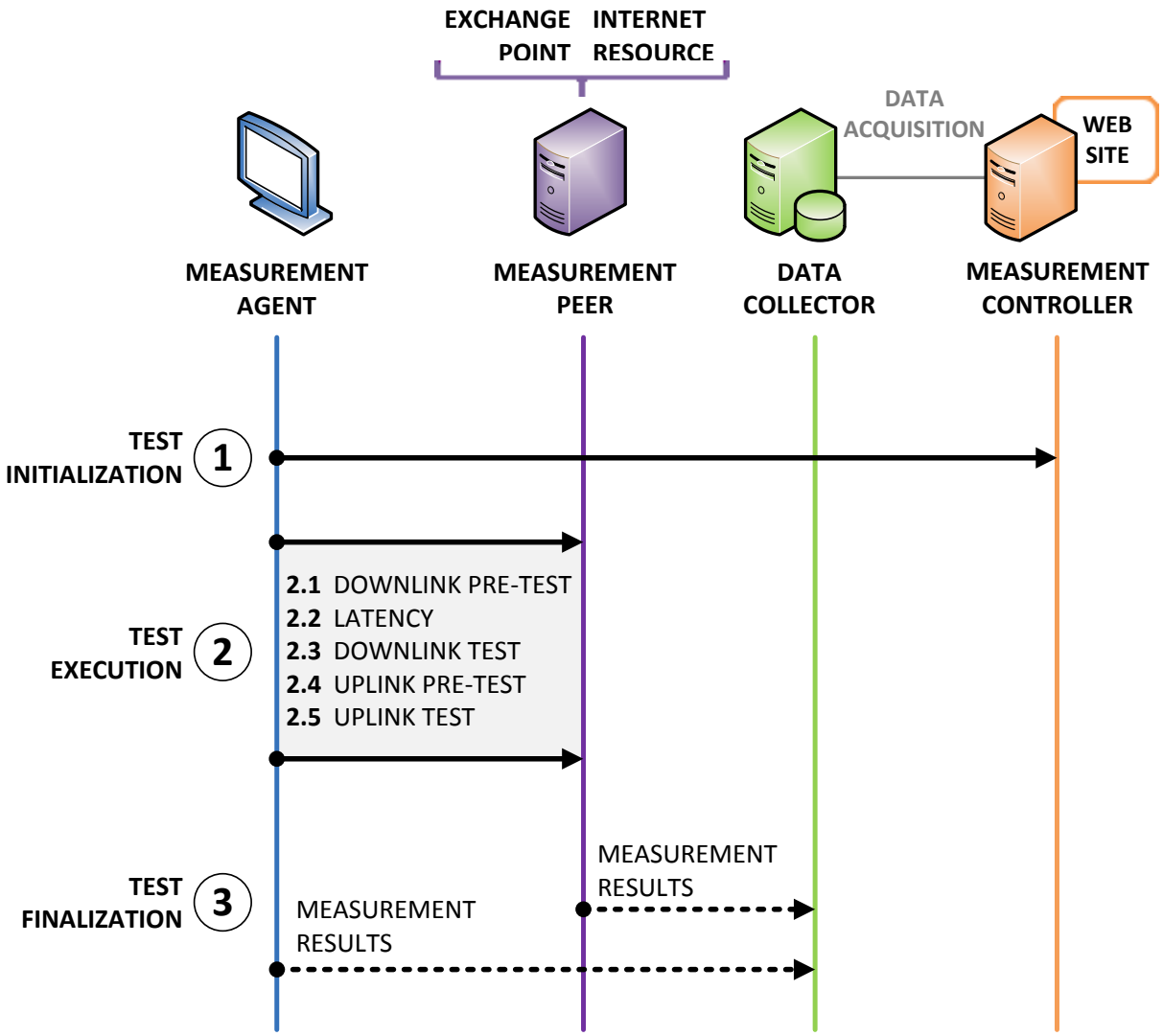


Figure 6. The workflow of the measurement system

**Step 1: Initialization** — Client connects to the Controller and after establishing a proper connection, client and server exchange the information, which is required for running the test. The test script may be uploaded from Controller to the particular Measurement Agent or measurement equipment (middlebox).

**Step 2: Execution** — Once the test is accessed in the Measurement Agent or measurement equipment (middlebox), it should be executed towards different Measurement Peers located in Exchange Points or Internet Resources. Even though the test methodologies to be used at this step will be specified in a separate ITU-T Recommendation, some guidelines are described here below:

- ***Step 2.1: Downlink pre-test***
  The downlink pre-test intends to evaluate and establish parameters for downlink subtest (Figure 7).

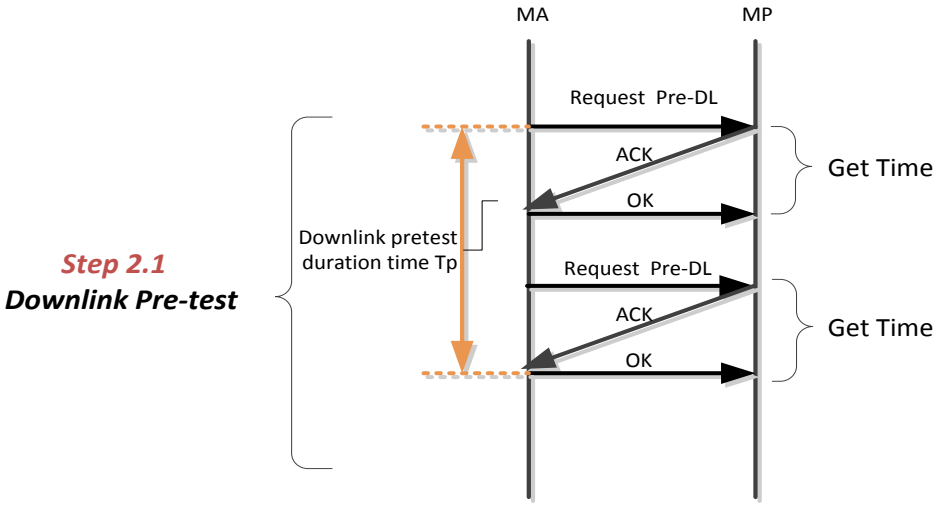


Figure 7. Example of Downlink Pre-test

- ***Step 2.2: Latency test***
  During this phase, the client sends p "pings" in short intervals to the Measurement Peer (MP) to test the latency of the connection (Figure 8).

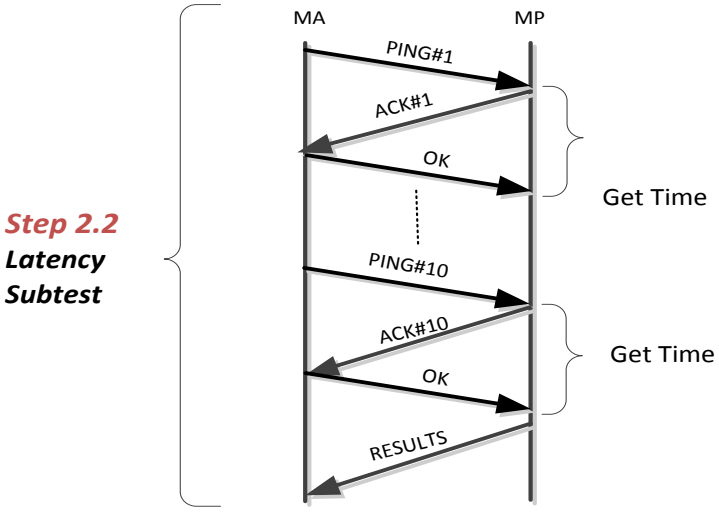


Figure 8. Example of Latency Test

- ***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 9).

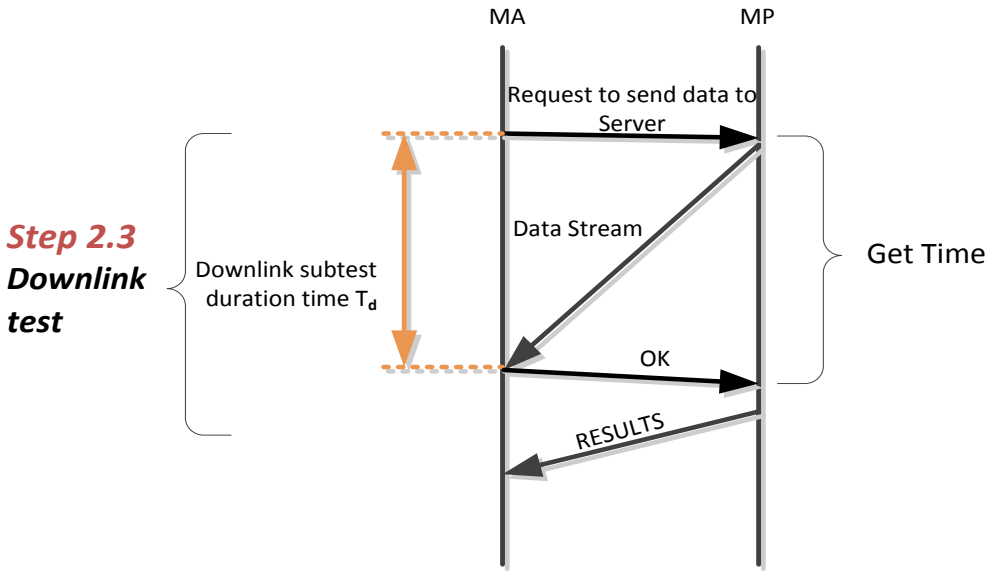


Figure 9. Example of Downlink Test

- ***Step 2.4: Uplink pre-test***
  The downlink pre-test intends to evaluate and establish parameters for uplink subtest (Figure 10).

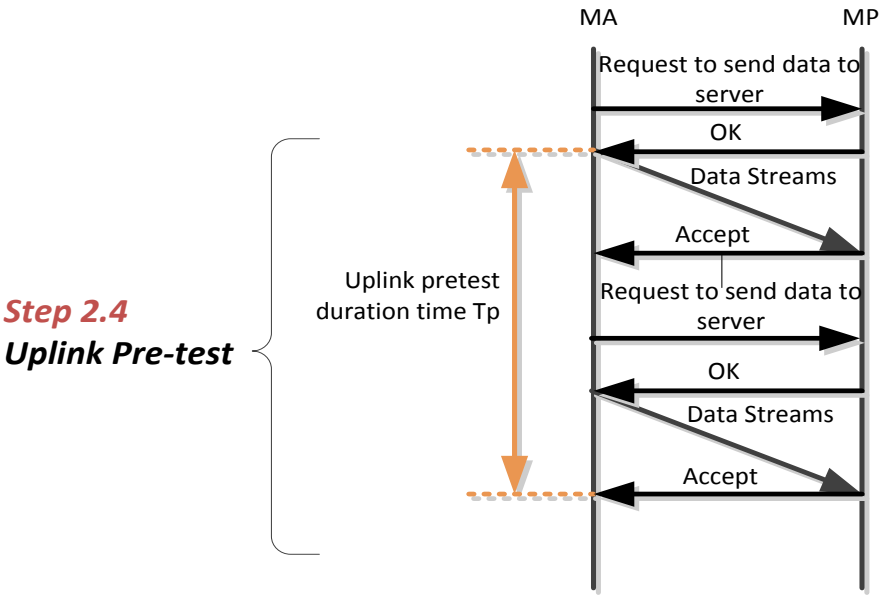


Figure 10. Example of Uplink pre-test

***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 11).

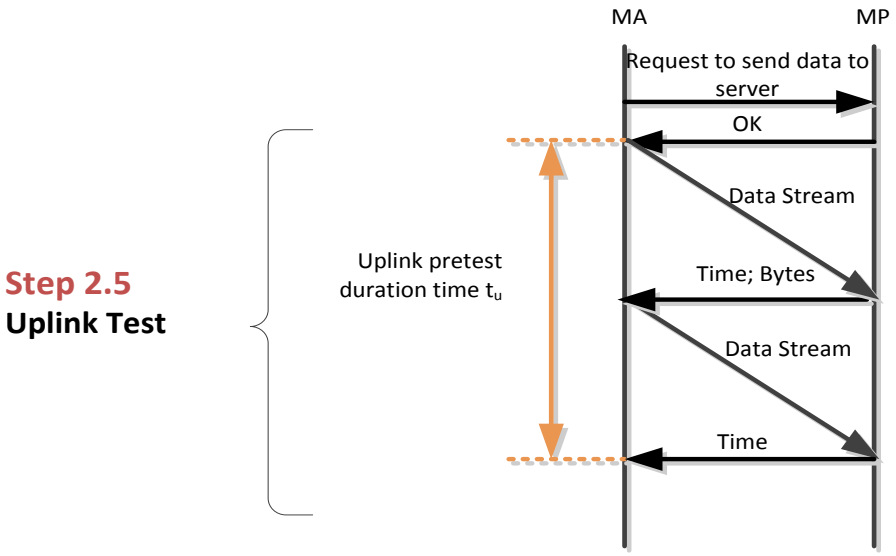


Figure 11. Example of Uplink Test

**Step 3: Finalization** — After finishing all tests, the client sends the collected data to the Collector (Figure 6). All results and additional information on the client are transferred to the Collector. Both datasets are then compared by the Collector to check 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 (browser, operating system) from their Measurement Agent should be collected for better statistical results evaluation. Collecting data on the user´s hardware and software configuration (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). Annex A represents a sample list of additional information collected from user´s platform and test parameters themselves.

Also, additional functionalities could be offered to the clients with the aim of collecting further information. For instance, the option of user's registration could be also available to facilitate users to share and compare their results and to access the historical 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 a requirement to use the test.

The Controller should have a 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.

## 12. Test parameters

At least the following parameters should be measured from/to the specific Measurement Peers by the proposed methodology (for both the Network Internet speed test and the Internet resource speed test):

- **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"* (ITU-T Rec. G.1050).[ACM30]

*Note: the test parameters and specific metrics will be specified in a separate ITU-T Recommendation.*

## Annex A

## List of additional information collecting from user´s hardware and software

The following information may be collected (not limited):

### 1. Information collected from user´s platform

#### *1.1 For fixed networks*

- User IP address;
- Operating system version;
- Web-browser version/User Agent (In case web technology is used);

*Note: according to https://www.netztest.at/en/ and section 12.1 of this Recommendation*

#### *1.2 **For mobile networks** (in addition to information for fixed networks):*

- SIM's network operator ID and name
- SIM's network country code and name
- Phone type (GSM, CDMA).

*Note: according to http://www.fcc.gov/measuring-broadband-america/mobile/technical-summary*

### 2. Test parameters information

#### *2.1 **For fixed networks**:*

- Test time;
- Time zone;
- TCP and UDP settings;
- Number of parallel connections (downlink and uplink);
- Duration of pre-test;
- Duration of the downlink subtest;
- Duration of the uplink subtest;
- Timeout value;
- Number of 'pings' during delay subtest;
- Maximum elapsed time between ping starts;
- Reference size of data block (chunk size);
- Number of received chunks after which the MP answers back to the MA
- WS advertised during the TCP negotiation phase for the different TCP streams: Regarding the warnings, although n parallel connections will be launched in the test, the server will calculate whether for the estimated RTT, OS (TCP flavour + typical Tx/Rx buffer sizes) and measured WS the calculated downlink and uplink speeds are too close (>90%) of the theoretical limitations, notifying the user about the unreliability of the test and the need to optimize his configuration for achieving better speeds.

#### *2.2 **For mobile networks** (in addition to information for fixed networks):*

- Location inferred from cell tower triangulation, WiFi triangulation, or GPS;
- Active cell tower ID and signal strength (RSSI);
- Visible neighboring cell towers, including cell IDs and RSSI;
- Active network operator ID ("MNC") and name;
- Active network country code ("MCC") and name;
- Bearer (CDMA, GPRS, EDGE, all of the 3G variants, LTE, etc);

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