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SERIES E: OVERALL NETWORK OPERATION,
TELEPHONE SERVICE, SERVICE OPERATION AND
HUMAN FACTORS

Quality of telecommunication services: concepts, models,
objectives and dependability planning – Models for
telecommunication services

**Crowdsourcing approach for the assessment of
end-to-end quality of service in fixed and mobile
broadband networks**

Recommendation ITU-T E.812

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Recommendation ITU-T E.812

Crowdsourcing approach for the assessment of end-to-end quality of service in fixed and mobile broadband networks

Summary

End-user equipment, consumer premise equipment and its software have evolved to become faster, more powerful and able to perform data collection. This has enabled the crowdsourcing approach which seeks to increase the amount of technical parameters which can be collected from end-users without modification to existing hardware and software.

Increasingly, players such as regulators and service providers have started to assess end-to-end quality of service (QoS) through a crowdsourcing approach. However, assessment using data collected through the crowdsourcing approach can be deployed in multiple ways and different approaches provide different views of QoS.

Recommendation ITU-T E.812 outlines the different crowdsourcing approaches used to assess end-to-end QoS on both fixed and mobile broadband networks.

History

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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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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Introduction

Providers of telecommunication services usually need to assess QoS from their networks, as it is a way to verify if the service is being adequately delivered to their end-users. The assessment of QoS may be important from the regulator's perspective as well, as quality improvements are often a critical item on the regulatory agenda. The collected data on quality issues can serve regulators as a guide to raise consumer awareness and to foster further improvements in the network infrastructure. One of the most important steps in telecommunication networks quality management is the definition and implementation of the quality monitoring and assessment approach. There are many solutions available for this task, and all of them have their own trade-offs between accuracy, temporal and geographic granularity and costs.

The crowdsourced approach is one of the possible methods for monitoring and assessing QoS in fixed and mobile broadband networks. Its basic assumption is to collect data from a large base of end-users, directly from end-user's equipment (for example, mobile devices and customer premise equipment (CPEs)). There are, however, many vendors that provide these kind of solutions, and they may differ significantly from each other. Differences include how the data is collected (if initiated by the end-user or if no intervention is required) or what type of data is collected (if a download test is performed or if the data just comes from the device/equipment regular usage). Crowdsourced data that are collected on multiple service provider's networks in the same market using the same data collection methodology will benefit from consistent data collection approaches and methodology across service providers.

The crowdsourcing approach increases the number of data points significantly as compared to the typical QoS assessment approach (e.g., drive/walk test). The large amount of data may strengthen the reliability and representativeness of the obtained results. Furthermore, it improves the use of resources and allows countries with larger geographical masses to leverage on the public to collect the data.

This Recommendation identifies advantages, disadvantages and precautions that should be considered when deploying such methods of QoS monitoring.

Recommendation ITU-T E.812

Crowdsourcing approach for the assessment of end-to-end quality of service in fixed and mobile broadband networks

1 Scope

This Recommendation covers the end-to end QoS assessment of fixed and mobile Internet access using the crowdsourcing approach, including:

- Overview of crowdsourcing approach for fixed and mobile Internet access;
- Types of crowdsourced data collection, characteristics and requirements;
- Set-up scenarios;
- Guidelines for regulators, service providers and vendors that can be used for benchmarking and network improvement when using the crowdsourcing approach.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this document, constitute provisions of this Recommendation. At the time of publication, the indicated editions indicated were valid. All Recommendations and other references are up for revision; users of these Recommendations 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.800] Recommendation ITU-T E.800 (2008), *Definitions of terms related to quality of service*.
- [ITU-T E.806] Recommendation ITU-T E.806 (2019), *Measurement campaigns, monitoring systems and sampling methodologies to monitor the quality of service in mobile networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 download [ITU-T E.800]: Transfer of data or programs from a server or host computer to one's own computer or device.

3.1.2 latency [b-ITU-T G.9961]: A measure of the delay from the instant when the last bit of a frame has been transmitted through the assigned reference point of the transmitter protocol stack to the instant when a whole frame reaches the assigned reference point of receiver protocol stack. Mean and maximum latency estimations are assumed to be calculated on the 99th percentile of all latency measurements. If retransmission is enabled for a specific flow, latency also includes retransmission time.

3.1.3 jitter [b-ITU-T G.9961]: A measure of the latency variation above and below the mean latency value. The maximum jitter is defined as the maximum latency variation above and below the mean latency value.

3.1.4 IP packet loss ratio (IPLR) [b-ITU-T Y.1540]: IP packet loss ratio (IPLR) is the ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest.

3.1.5 crowdsourcing [b-ITU-T P.912]: Obtaining the needed service by a large group of people, most probably an on-line community.

3.1.6 end-to-end quality [ITU-T E.800]: Quality related to the performance of a communication system, including all terminal equipment.

3.1.7 quality of service [ITU-T E.800]: Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.

3.1.8 crowdsourced data collection [ITU-T E.806]: A method to gather active and/or passive quality of service measurements from a large number of end-user devices.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CDN	Content Delivery Network
CPE	Customer Premise Equipment
CPU	Central Processing Unit
GNSS	Global Navigation Satellite System
HTTPS	Hypertext Transfer Protocol Secure
IoT	Intert of Things
IP	Internet Protocol
IXP	Internet Exchange Point
KPI	Key Performance Indicator
MCC	Mobile Country Code
MNC	Mobile Network Code
OTT	Over-the-top
PoP	Point of Presence
QoS	Quality of Service
RAM	Radom-access Memory

5 Conventions

None.

6 Overview

[b-ITU-T P.912] defines in its Annex I the term crowdsourcing as "obtaining the needed service by a large group of people, most probably an on-line community." In this sense, it is implied that the main feature of crowdsourcing is to involve a large number of people. This concept can be applied to a varied range of purposes, like raising funds, sharing tasks or pooling results from opinion tests.

When it comes to the context of monitoring the QoS for fixed and mobile broadband networks, the crowdsourced approach can be understood as the gathering of data from a large base of end-users, with the goal of assessing the QoS of the employed network infrastructure, as a means to serve the consumers' needs. This can be done through the employment of software and hardware that collect

QoS-related data directly from end-user's CPEs (such as routers) or mobile devices (such as tablets and smartphones). In the case of fixed broadband, embedded software in the consumer's premises equipment, which is usually supplied by the service provider, can collect QoS-related information. In the mobile service perspective, a similar set of data may be gathered, for instance, by software that can be downloaded on mobile devices.

A wide range of data can be collected from the CPEs and mobile devices (collectively known as "data collection device" in this Recommendation) when using crowdsourcing solutions that is useful for the QoS assessment of fixed and mobile broadband connection. They may include, but are not limited to:

- Location (e.g., GNSS coordinates),
- Date and Time (e.g., duration, etc.),
- Service provider (e.g., home and visited networks for mobile and internet service provider for fixed broadband),
- Network information (e.g., access point name, signal strength, cell information),
- Type of connection (e.g., Ethernet, Wi-Fi, 3G, 4G, 5G, etc.),
- Device information (e.g., manufacturer, model, etc.),
- Device usage (e.g., data usage, central processing unit (CPU) usage, battery level, concurrent traffic, etc.).

This collected data can provide relevant QoS indicators for broadband networks, such as throughput, latency, jitter, packet loss, among others. These are basic parameters that characterise the end-to-end performance and can be used to infer service quality.

7 Types of crowdsourced data collection, technical characteristics and requirements

Crowdsourced data collection is categorized into active and passive measurements, as introduced by [ITU-T E.806]. The data collection process can be initiated by the end-user or programmatically. Different configurations can be chosen to cater to the different needs.

Crowdsourced based solutions may include active and passive measurements. Hybrid solutions can use both.

7.1 Types of crowdsourced data collection

Each type of data collection method has its own sets of advantages and challenges which will be addressed in the following clauses. While a QoS indicator can be collected using both methods, the choice of method can reflect the same indicator differently. For example, the throughput collected from an active measurement may reflect closer to the performance of the network while the throughput collected from a passive measurement may reflect closer to the end-users' actual usage.

7.1.1 Active measurements

Active data collection methods create artificial traffic with the intention to assess end-to-end QoS parameters. For example, intentional file transfer with the aim to measure the throughput, ping tests, among others. The active approach is illustrated in Figure 1.

Active tests may be specifically designed to saturate the network, and therefore produce a more accurate measure representing the peak end-to-end performance at the point of test. However, attention must be directed towards the analysis of the results to ascertain its reliability and representativeness. To this end, clauses 7.3.1 and 7.3.2 outline considerations for the proper processing and statistical analysis of data.

When measuring the end-to-end performance using an active test, many factors can be controlled, such as, the test duration, the test server location, the number of simultaneous streams, the size of