

# Recommendation

## **ITU-T Q.4078 (04/2025)**

SERIES Q: Switching and signalling, and associated measurements and tests

Testing specifications – Testing specifications for IMT-2020 and IoT

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**User requirements and reference model for testbed as a service**

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*For further details, please refer to the list of ITU-T Recommendations.*

# Recommendation ITU-T Q.4078

## User requirements and reference model for testbed as a service

### Summary

Recommendation ITU-T Q.4078 elaborates on requirements and reference model, with properties of relevance for delivering testbed as a service (TaaS) in the context of federated testbeds, aiming to complement and extend Recommendation ITU-T Q.4068. It is more particularly focused on the user interface, services, and requirements to address end-user needs when remotely accessing testbeds in order to deliver an adequate user experience. From this point, this Recommendation is reporting the elaboration of the related terms and definitions, requirements, reference model with properties of relevance for TaaS, and interoperability specifications for virtualizing and delivering modular and scalable TaaS on top of existing and future testbed infrastructures, including federated ones. Furthermore, the TaaS will be able to list the assets provided by the different testbeds and expose them through dedicated application programming interfaces (APIs) based on Recommendation ITU-T Q.4068. Generic key performance indicators (KPIs) are defined in a generic manner in the corresponding Recommendation; for instance, the exposure of capabilities is a generic KPI, so agnostic from the TaaS, and is common to all the parts of a testbed federation. Some KPIs concerning specially the TaaS are determined in this Recommendation such as dynamic discovery, availability and reputation based on a scoring of each testbed. Integration, interoperability and extensibility of the TaaS are also defined.

### History \*

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Q.4078	2025-04-13	11	11.1002/1000/16294

### Keywords

Reference model, requirements, testbed as a service (TaaS), testbed federation.

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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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# Recommendation ITU-T Q.4078

## User requirements and reference model for testbed as a service

### 1 Scope

This Recommendation defines the specific user requirements and reference model for testbed as a service (TaaS). It also describes the interconnection of testbeds through the testbed management system and considers other aspects like business, policies and monetization.

### 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 Q.4068](#)] Recommendation ITU-T Q.4068 (2021), *Open application program interfaces (APIs) for interoperable testbed federations*.

### 3 Definitions

#### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 experiment** [b-ISO 3534-3]: Purposive investigation of a system through selective adjustment of controllable conditions and allocation of resources.

**3.1.2 resource** [b-ITU-R BT.1699]: A network data object or a service which is uniquely identified in a network. – A well-defined capability or asset of a system entity, which can be used to contribute to the realization of a service. Examples: MPEG decoder, graphics system.

**3.1.3 testbed** [ITU-T Q.4068]: Platform to realise scientific tests with new technologies on an environment fully controlled by experimenters.

**3.1.4 testbed as a service** [b-ITU-T QSTR.FTT]: Refers to the offering of a testbed by its owner to users based on a defined policy framework. This framework may include service level agreements (SLAs), pricing models, usage time frames, and testbed availability. Users can access the testbed to run tests, analyze results, and utilize the findings while adhering to the established policies.

#### 3.2 Terms defined in this Recommendation

None.

### 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
API	Application Programming Interface
CPU	Central Processing Unit
FTTH	Fiber to the Home

GDPR	General Data Protection Regulation
GUI	Graphical User Interface
IoT	Internet of Things
KPI	Key Performance Indicator
ML	Machine Learning
QoS	Quality of Service
RAM	Random-Access Memory
SDN	Software-Defined Networking
TaaS	Testbed as a Service
xDSL	Any type of Digital Subscriber Line

## 5 Conventions

None.

## 6 User requirements and reference model for testbed as a service

There are two types of users to be involved in the testbed as a service (TaaS):

1. The experimenters or researchers, simply called users throughout this Recommendation;
2. The testbed providers which are responsible for the implementation and the maintenance of the TaaS.

There are the following functional requirements pertaining to the TaaS users' needs:

- Resource discovery: The users should be able to discover the specific resources for all available federated testbeds.
- Resource provisioning: Mechanisms for provisioning resources by the users should be implemented, including the access and the orchestration of resources.
- Resource configuration: The users should be able to configure the resource by changing the value or range of values of one or several parameters before an experiment.
- Resource description: An understandable description of each resource should be provided to the users.
- Resource reservation: Users should be able to reserve the resources in different modes such as a scheduled reservation or on-demand.
- Experiment control and orchestration: The users should be able to control various parameters during the execution of an experiment. The users should be able to manage the full lifecycle of their experiments through a dashboard.
- Authentication: The users should authenticate themselves to access the TaaS.
- Authorization: The users should receive authorization to use the resources provided by the testbeds.
- Monitoring, results gathering and reporting: The users should be able to track which parameters should be monitored during an experiment and to collect the results of the experiment, including generation of an experiment's report.
- Interconnection of testbeds: The users should be able to select resources distributed among several testbeds.
- User interface: The users should be able to manage their experiments through a graphical user interface (GUI).



- Remote access: The users should be able to access the TaaS remotely.
- Data analytics tools: The users should be able to use data analytics tools offered by the TaaS.
- Experiment discovery and selection: The users should be able to find and use past experiments. A clear description of an experiment and related test suites are also required as prerequisite.
- Experiment storage: The users should be able to store finished experiments and their results in order to execute them again later, if needed.
- Automated experiment scheduling: The users should have the ability to automate the scheduling of experiments based on predefined criteria, such as recurring tests or experiments triggered by external events (e.g., data threshold reached, network status change).
- Notifications and alerts: The users should be able to set up custom notifications or alerts for certain conditions (e.g., experiment status changes, resource availability, or experiment completion).

The functional requirements concerning the testbed providers are:

- Resource description, catalogue provisioning: The testbed providers should describe and list their testbeds in their catalogue, including the available resources and their capabilities. A common description/advertisement scheme should be applied for all the resources of all the testbeds available under publish/subscribe model.
- Resource identification: The resources should be clearly identified by unique identifiers used across all the testbeds.
- Resource reservation: The testbed providers should continuously update the information related to the status of the reservation of their resources.
- Resource provisioning: The testbed providers should operate provisioning systems and expose them through open APIs/interfaces to the rest of the testbed federation.
- Experiment control: The testbeds should be able to work with tools used to control the experiments.
- Management of testbeds: A testbed management system should be owned by the testbed providers. A testbed provider can change the policies of the testbed management system. Network programmability and software-defined networking (SDN) solutions could be envisioned to control in fine-grained manner the interworking aspects between the testbeds.
- Documentation: The testbed providers should make the TaaS manual publicly available. It should be updated on a regular basis.
- Consumption of the service: The testbed providers should provide a usage and billing services which inform the users about the utilisation of the TaaS. This service should also handle the invoices to be addressed to the users.
- Scalability: The testbed providers should ensure the scalability of the TaaS, allowing the execution of experiments to scale based on needs.
- High availability: The testbeds should be designed with high availability, minimizing downtime and ensuring continuous service availability.
- Access control: The system should support different user roles (e.g., administrator, researcher, testbed provider) with specific access control policies, ensuring that users can access only the resources and features they are authorized to use.
- Artificial intelligence (AI) / machine learning (ML) integration: The TaaS should support AI/ML models to optimize resource allocation and experiment configuration, as well as help predict potential issues in experiments based on historical data.

The non-functional requirements are listed below:

- User-friendliness: The users should utilise the TaaS GUI according to the guidelines and the best practices in terms of user-friendliness.
- Security and confidentiality: The TaaS should comply with relevant standards in this area, the best practices about security and the applicable regulation for data protection, such as the general data protection regulation (GDPR) and other data protection regulations. An approach following the security and privacy by design principles is recommended (e.g., the critical data shall be encrypted).
- Visualization: The users should be able to see real-time information during the execution of an experiment. After the completion of an experiment, they should be able to have access to the results and the logs for further analysis and other purposes (e.g., downloading results). The formats of the results should be generic enough in order to be customised for various purposes.
- Latency optimization: TaaS should minimize latency between testbed resources and experimenters' actions, especially for real-time or time-sensitive experiments, by optimizing data transfer, resource allocation, and orchestration mechanisms.

For the TaaS, there are the following key performance indicators (KPIs):

- Dynamic discovery: The discovery of all the resources provided by all the testbeds is realized dynamically and all the discovered resources are displayed in the TaaS GUI in real time. It will permit to evaluate the number of resources provided by the testbeds.
- Availability: The availability of the testbeds and their resources are also shown in the TaaS GUI. It will allow the detection of problems per testbed, notably network disconnections. This KPI can be used to improve the quality of service (QoS).
- Reputation based on testbed rating: The broker is maintaining and updating the rating of each testbed. In the same manner, the collection of the information provided by the users is done in order to rate each testbed.
- Number of open user sessions (active or idle): This KPI permits to know how many users are currently using the TaaS.
- Resource utilization efficiency: This KPI tracks the efficiency of resource utilization in the testbed, providing insights into over-provisioning or under-utilization of resources, which could drive cost reduction and better planning.

In the context of the TaaS, a conformity assessment of testbeds should be based on some criteria such as data protection, security, audit of the components, specifications and standards including those defined in [ITU-T Q.4068]. A test tool offered by the TaaS can be used to assess whether reserved resources are in conformity with the regulation or not (e.g., data processed in different locations/countries, insufficient central processing unit (CPU) / random-access memory (RAM) or detected congestions), which can be used as evidence in reconciliations before trials on the implications of third-party testing.

A tool can be declared compliant to carry out tests, for example diagnostic tests, by all the actors agreeing or having the tools recommended/prescribed by a regulator to the different stakeholders such as operators, regulators themselves, auditors, test manufacturers. An important point is to know if the tests are to be carried out and on which specification releases (4G, 5G, 6G, fibre to the home (FTTH), any type of digital subscriber line (xDSL), cloud, etc.) but also whether they comply with relevant legislations (e.g., related to cloud, AI, data protection like GDPR).

## Bibliography

- [b-ITU-T QSTR.FTT] ITU-T Technical Report QSTR.FTT, *Federated testbeds taxonomy*
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