Project: H2020-ICT-688712

Project Name:

5G Applications and Devices Benchmarking (TRIANGLE)

D2.2 Appendix 10

Test Specification

IoT devices Data Performance (IDP)

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Contents

List of Figures

List of Tables

1 Introduction

1.1 Purpose

The test cases defined in this Test Specification measure the data performance of an IoT device in normal operation.

This test specification describes basic measurements that are representative of the main uses of an IoT device to determine the data performance of the device.

1.2 Scope of testing

This Test Specification is applicable to IoT devices.

The test cases included in this test specification are designed to obtain Key Performance Indicators (KPIs) to determine IoT devices performance in the IoT devices Data Performance TRIANGLE domain.

The KPIs obtained are used by the IoT devices Data Performance metric to obtain the IoT device TRIANGLE mark.

The test cases in this Test Specification are initially defined to be implemented in TRIANGLE testbed.

1.3 Definitions and Acronyms

Table 1 – Definitions

State	Description
Backend Service	Remote endpoint of the service layer
Network Scenario	usage scenario as described in Deliverable D2.2 [1] which is defined by a parameterization of the air interface and the core network
Test System	Integrated system used to measure the performance of the IoT device against this test specification.
TRIANGLE Testbed	TRIANGLE testing framework. It covers all the software, and the coordination/sequencing that control & connects to the test infrastructure. It is in charge of handling and transforming the end user test requests into actionable steps for the software and hardware components of the testbed.

Table 2 – Acronyms

State	Description
AR	Augmented Reality
CPU	Central Processing Unit
CS	Content Distribution Streaming Services
CV	Connected Vehicles
DUT	Device Under Test
EM	Emergency Services
GA	Gaming
GPU	Graphics Processing Unit
HS	High Speed Internet
ICS	Implementation Conformance Statement
IDP	IoT devices Data Performance test specification
IUT	IoT device Under Test
IXIT	Implementation eXtra Information for Testing
ksps	KiloSamples per second (thousands of samples per second)
LS	Live Streaming services
PM	Patient Monitoring
SG	Smart Grids
SM	Smart Metering
SN	Social Networking
VR	Virtual Reality

1.4 References

[1] D2.2 Formalization of the certification process, requirements and use. Appendix 2: Product characterization.

2 General Test conditions

Unless otherwise specified in a particular test case, the conditions defined in this section will apply for all test cases.

2.1 Test System configuration

The figure below shows a simplified overview of the testing architecture.

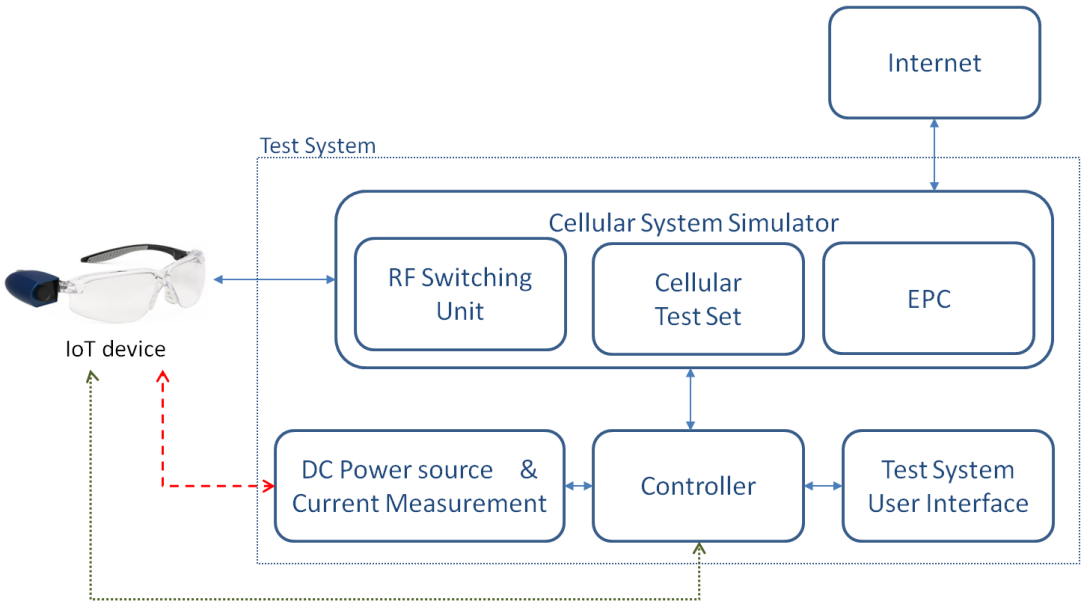

Figure 1 – Test System architecture overview

The IoT device is connected to the Test System though a conducted RF connection.

The DC Power Source and Current Measurement device provides DC power source to the IoT Device and measures the IoT Device current consumption.

The DC Power Source will have the following functionalities:

- Configurable output voltage.
- Output Resolution at least 0.01 volt.
- Output voltage range including the nominal voltage of the Host device (+- 5%)
- Remote sensing recommended; for the maintenance of the nominal voltage of the IUT.
- Enough continuous and peak output current capability to cover IUT requirements during the measurements.

The Current measurement device will have the following functionalities:

- Measurement resolution: At least 0.1 mA.
- Sampling frequency: No less than 50 ksps

In the case of battery operated IoT devices, the battery will be replaced by a dummy battery fixture.

The dummy battery shall provide a connection between the IoT Device battery terminals and the DC power source.

The dummy battery will provide means to minimize, as far as possible, the resistance, inductance and length of cables required to connect the fixture to the DC power supply.

The dummy battery may provide source and sense conductors to keep the nominal battery voltage as stable as possible.

In the case of grid operated IoT devices, the IoT device will be connected to the DC power source by the appropriate connector, trying to minimize the resistance, inductance and length of cables required.

The Test System is configured to perform the test cases will be one of the bands supported by the IoT Device. In case any of the bands listed next is supported by the device it will be selected and in the order defined: 1. FDD4; 2.FDD17; 3. FDD14; 4. FDD25; 5. FDD2; 6. FDD5; 7. FDD7; 8. FDD12; 9. FDD12; 10. FDD30.

Note: It is recommended that the IoT Devices always use the same frequency band, as it may affect the results obtained.

The Test System network is initially configured as specified by the latest release of 3GPP TS 36.508.

2.2 IoT device configuration

The IoT device will be configured according to the standard configuration provided by the supplier in the IoT device user manual.

- If the IoT device has an screen, it will be configured as follows:
  - Maximum brightness available
  - Maximum screen resolution available.
  - No Energy saving or screen saving option is enabled.
- The IoT device is allowed to use mobile data.
- There is no restriction configuration for data use.
- If the IoT device supports audio Volume, it is configured at the middle of the available range.
- The IoT device is ON for at least two minutes to allow all boot processes to be completed.

2.3 Network Scenarios Applicability

The test cases will be executed for each of the Network Scenarios applicable for each Use Case as shown in Table 3.

Table 3 – Use Case / Network Scenarios Applicability

	Network Scenario	Use Cases				
SC	**Network Scenario**	**PM**	**ES**	**SM**	**SG**	**CV**
UR-OF	Urban-Office		Y	Y		
UR-PE	Urban-Pedestrian					
UR-DN	Urban-Driving-Normal	Y				Y
UR-DT	Urban-Driving-Traffic jam	Y				Y
UR-DE	Urban-Driving-Emergency driving	Y	Y			Y
UR-IB	Urban-Internet Café, Busy Hours					
UR-IO	Urban-Internet Cafe, Off-Peak					
SU-FE	Suburban-Festival		Y			
SU-ST	Suburban-Stadium		Y			
SU-SB	Suburban-Shopping Mall, Busy Hours		Y			
SU-SO	Suburban-Shopping Mall, Off-Peak		Y			
HS-RE	High Speed-Relay					Y
HS-DP	High Speed-Direct Passenger Connection					Y
IT-WA	Internet of Things-Warehouse			Y		
IT-OS	Internet of Things-Outdoor Sensors			Y	Y	
IT-HS	Internet of Things-Home Sensors	Y		Y	Y	

2.4 Number of Test Iterations

In order to obtain statistically relevant measurements out of which the KPIs will be derived, the test cases will be iterated 100 times, except for the following tests that will be iterated as shown in Table 4.

Table 4 – Test case Iterations

Test Case	**# of Iterations**
TBD	tad

2.5 Test Case Initial Conditions (Preamble)

Following initial conditions modes are defined:

IUT-STARTED

- The IUT is ON.
- The IUT is configured as specified in section 2.2.
- The Test System and the IUT are connected as shown in figure 1.
- The IUT Backend Service (if existing and required) is accessible from the Test System.
- Test Environment Lightning: Office conditions with no direct sun light on the IUT.
- The Test System is configured according to the target Network Scenario as defined in D2.2 Appendix 8 (Network scenarios parameterization).
- The Test System has established a data path with the IUT.

2.6 Test Case Final Condition (Postamble)

Unless stated otherwise in the test case description, the following steps will be executed after the test case steps:

- The Test System shuts down the data path with the IUT.

2.7 IoT Device Control Interface

The IUT will provide a Control Interface to allow TRIANGLE testbed perform the following actions on it. IUTs shall implement the actions related to supported ICS.

Table 5 – Control Interface functionality

ICS	**Action**	**Description**
ICSDI_RecordVideo	Send live video streaming	Transmit a live video streaming
ICSDI_RecordAudio	Send live audio streaming	Transmit a live audio streaming
ICSDI_PlayVideo	Receive live video streaming	Play a live video streaming’
ICSDI_PlayAudio	Receive live audio streaming’	Play a live audio streaming’

3 Test cases

3.1 Common

The tests cases in this section apply to all Use Cases.

3.1.1 IUT in idle mode

Identifier: IDP/*CO/001*

Title: IUT in idle mode

Objective: Measure the IUT data performance when it is in idle mode.

Applicability:

(ICSG_ProductType = IoT device) AND ICSDI_IdleMode

Initial Conditions:

AUT is in [AUT NOT RUNNING] mode.

Steps:

1. The Test System measures the data performance of the IUT in Idle mode during 20 minutes (as defined in the measurements section).

Postamble:

- Execute the Postamble sequence (see section 2.6).

Measurements:

- Data passing through PDSCH.
- Data passing through PDCCH.
- Data passing through PUSCH.
- Data passing through PUCCH.
- Data passing through UL/DL PDCPs.
- Data passing through UL/DL S1-U.
- Data passing through UL/DL S1-MME.
- Data passing through UL/DL S5/ePDG.
- Number of established bearers.
- Type of established bearers.
- Number of opened TCP/UDP connections.

3.2 ES Emergency Services

3.2.1 Send Video streaming

Identifier: I*DP/ES/001*

Title: Send Video Streaming

Objective: Measure the IUT data performance while executing the feature Send Video Streaming from the Emergency Services use case.

Applicability:

(ICSG_ProductType = IoT device) AND (ICSG_UseCases includes ES) AND ICSDI_RecordVideo

Initial Conditions:

IUT is in [IUT STARTED] mode.

Steps:

1. The Test System commands the IUT by the Control Interface to perform the feature 'Send Stream live video'.
2. After ten seconds, the Test System measures the data performance of the IUT for 20 minutes.
3. The Test System commands the IUT by the Control Interface to perform the feature 'Stop sending stream live video'.

Postamble:

- Execute the Postamble sequence (see section 2.6).

Measurements:

- Data passing through PDSCH.
- Data passing through PDCCH.
- Data passing through PUSCH.
- Data passing through PUCCH.
- Data passing through UL/DL PDCPs.
- Data passing through UL/DL S1-U.
- Data passing through UL/DL S1-MME.
- Data passing through UL/DL S5/ePDG.
- Number of established bearers.
- Type of established bearers.
- Number of opened TCP/UDP connections.

3.2.2 Send Audio streaming

Identifier: I*DP/ES/002*

Title: Send Audio Streaming

Objective: Measure the IUT data performance while executing the feature Send Audio Streaming from the Emergency Services use case.

Applicability:

(ICSG_ProductType = IoT device) AND (ICSG_UseCases includes ES) AND ICSDI_RecordAudioWithoutVideo

Initial Conditions:

IUT is in [IUT STARTED] mode.

Steps:

1. The Test System commands the IUT by the Control Interface to perform the feature 'Send streaming live audio.
2. After ten seconds, the Test measures the data performance of the IUT for 20 minutes.
3. The Test System commands the IUT by the Control Interface to perform the feature 'Stop streaming live audio.

Postamble:

- Execute the Postamble sequence (see section 2.6).

Measurements:

- Data passing through PDSCH.
- Data passing through PDCCH.
- Data passing through PUSCH.
- Data passing through PUCCH.
- Data passing through UL/DL PDCPs.
- Data passing through UL/DL S1-U.
- Data passing through UL/DL S1-MME.
- Data passing through UL/DL S5/ePDG.
- Number of established bearers.
- Type of established bearers.
- Number of opened TCP/UDP connections.

3.2.3 Receive Video streaming

Identifier: I*DP/ES/003*

Title: Receive Video Streaming

Objective: Measure the IUT data performance while executing the feature Receive Video Streaming from the Emergency Services use case.

Applicability:

(ICSG_ProductType = IoT device) AND (ICSG_UseCases includes ES) AND ICSDI_PlayVideo

Initial Conditions:

IUT is in [IUT STARTED] mode.

Steps:

1. The Test System commands the IUT by the Control Interface to perform the feature 'Receive live video streaming'.
2. After ten seconds, the Test System measures the data performance of the IUT for 20 minutes.
3. The Test System commands the IUT by the Control Interface to perform the feature 'Stop receiving live video'.

Postamble:

- Execute the Postamble sequence (see section 2.6).

Measurements:

- Data passing through PDSCH.
- Data passing through PDCCH.
- Data passing through PUSCH.
- Data passing through PUCCH.
- Data passing through UL/DL PDCPs.
- Data passing through UL/DL S1-U.
- Data passing through UL/DL S1-MME.
- Data passing through UL/DL S5/ePDG.
- Number of established bearers.
- Type of established bearers.
- Number of opened TCP/UDP connections.

3.2.4 Receive Audio streaming

Identifier: I*DP/ES/004*

Title: Receive Audio Streaming

Objective: Measure the IUT data performance while executing the feature Receive Audio Streaming from the Emergency Services use case.

Applicability:

(ICSG_ProductType = IoT device) AND (ICSG_UseCases includes ES) AND ICSDI_PlayAudioWithoutVideo

Initial Conditions:

IUT is in [IUT STARTED] mode.

Steps:

1. The Test System commands the IUT by the Control Interface to perform the feature 'Stream live audio.
2. After ten seconds, the Test System measures the data performance of the IUT for 20 minutes.
3. The Test System commands the IUT by the Control Interface to perform the feature 'Stop streaming live audio'.

Postamble:

- Execute the Postamble sequence (see section 2.6).

Measurements:

- Data passing through PDSCH.
- Data passing through PDCCH.
- Data passing through PUSCH.
- Data passing through PUCCH.
- Data passing through UL/DL PDCPs.
- Data passing through UL/DL S1-U.
- Data passing through UL/DL S1-MME.
- Data passing through UL/DL S5/ePDG.
- Number of established bearers.
- Type of established bearers.
- Number of opened TCP/UDP connections.

4 Test cases applicability

The applicability of each individual test is identified in Table C.1.

The applicability of every test is formally expressed by the use of Boolean expressions that are based on parameters (ICS) included in annex A of the present document.

The columns in Table C.1 have the following meaning:

Test case column

The Test case column indicates the test case number for each test case as described in the Control Panel Service Framework test case specification for which the applicability is identified.

Description column

The Title column indicates the title of each test case as described in the Control Panel Service Framework test case specification for which the applicability is identified.

Release column

The Release column indicates the earliest release from which each test case is applicable, except if otherwise stated of an individual test case.

Status column

The following notations are used for the Status column:

A	applicable - the test is applicable.
O	optional – the capability may be supported or not.
N/A	not applicable – in the given context, the test case is not applicable.
Ci	conditional – the test is applicable ("A") or not ("N/A") depending on the support of other optional or conditional items. "i" is an integer identifying an unique conditional status expression which is defined immediately following the table. For nested conditional expressions, the syntax "IF ... THEN (IF ... THEN ... ELSE...) ELSE ..." is used to avoid ambiguities.

The conditional expressions are added in the last row of the table. These expressions may use ICS as defined in D2.2 Appendix 2. ICS/IXIT. The ICS items will be referred as A.n/m where A.n refers to the table in which the ICS is defined and m refers to the item of the table.

A practical example is detailed below Table 6.

Table 6 – Test cases applicability

Test case	Description	Status
IDP/CO/001	IUT in idle mode	C01
IDP/ES/001	Send video streaming	C02
IDP/ES/002	Send Audio streaming	C03
IDP/ES/003	Receive video streaming	C04
IDP/ES/004	Receive audio streaming	C05
C01	IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/5 THEN **A** ELSE **N/A**	
C02	IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/1 THEN **A** ELSE **N/A**	
C03	IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/6 THEN **A** ELSE **N/A**	
C04	IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/3 THEN **A** ELSE **N/A**	
C05	IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/7 THEN **A** ELSE **N/A**	

Example of expression interpretation in the table above.

Table 7 – Example of test case applicability

Test case	Test case title	Status
IDP/CO/001	IUT in idle mode	C01

The status (applicability) of test case 'IDP/CS/001' is defined by condition' C01'

C01 IF (A.1/1= IoT device) AND (A.1/3 includes ES) AND A.4/5 THEN **A** ELSE **N/A**

Where:

C01:	Condition to be used in the test cases to define applicability
A.1/1	Value of Item 1 of table A.1 defined in D2.2 Appendix 2. ICS/IXIT In this case, value of ICS 'ICSG_ProductType' (Table A.1, item 1)
A.1/3 includes ES	ES is one of the values of ICS 'ICSG_UseCases' (table A.1, item 3). (ICSG_UseCases ICS status is Mn, meaning that several options may be supported.

If the value of the sub-expresion (A.1/1= IoT Device) is TRUE AND the value of the sub-expression (A.1/3 includes ES) is TRUE, *AND the value of tem 5 of table A.4 is TRUE,* the test case status is Applicable (A); in any other case, the status is Not-applicable (N/A).

5 Annex 1: Key Performance Indicators

The following table summarizes the Key Performance Indicators that will be obtained based on the measurements obtained by the execution of the test cases and each test case repetition.

Table 8 – Application User Experience Key Performance Indicators

Measurements	**Use Cases**	**Type**	**Unit**	**Summarization**	**KPI**
PDSCH data	ES	Unsigned Integer	bit	Average, Deviation, CDF	OTA DL U-plane throughput
PDCCH data	ES	Unsigned Integer	bit	Average, Deviation, CDF	OTA DL C-plane throughput
PUSCH data	ES	Unsigned Integer	bit	Average, Deviation, CDF	OTA UL U-plane throughput
PUCCH data	ES	Unsigned Integer	bit	Average, Deviation, CDF	OTA UL C-plane throughput
UL/DL PDCPs data	ES	Unsigned Integer	bit	Average, Deviation, CDF	PDCP-SAP goodput UL/DL
Number of established bearers	ES	Unsigned Integer	n/a	Average, Deviation, CDF	number of bearers
Number of opened TCP/UDP connections	ES	Unsigned Integer	n/a	Average, Deviation, CDF	number of transport connections
UL/DL S1-U data	ES	Unsigned Integer	bit	Average, Deviation, CDF	burst inter-generation time at transport level
UL/DL S1-MME data	ES	Unsigned Integer	bit		