



GROUP REPORT

Context Information Management (CIM); Validation of NGSI-LD test Platform and Examples of uses

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Contents

Intellectual Property Rights	5
Foreword.....	5
Modal verbs terminology.....	5
1 Scope	6
2 References	6
2.1 Normative references	6
2.2 Informative references.....	6
3 Definition of terms, symbols and abbreviations.....	6
3.1 Terms.....	6
3.2 Symbols.....	6
3.3 Abbreviations	7
4 NGSI-LD Interface Test Validation	7
4.1 Introduction	7
4.2 Test Environment	7
4.2.1 Implementation Under Test (IUT)	7
4.2.2 Test Equipment.....	8
4.2.3 Test Environment.....	8
4.2.4 Test case	9
4.3 Update history about NGSI-LD interface test code.....	10
4.3.1 Introduction.....	10
4.3.2 Test cases Design.....	10
4.3.3 Validation	11
4.3.4 Validation Result	11
4.3.5 Update History.....	14
4.3.5.0 Introduction.....	14
4.3.5.1 Deletion of Unnecessary Retrieve Request for Test Purpose.....	14
4.3.5.2 datasetid	14
4.3.5.3 Mismatch between Test Standards and Test equipment.....	14
5 NGSI-LD based Data Model Test Validation	15
5.1 Introduction	15
5.2 Test Environment	15
5.2.1 Implementation Under Test	15
5.2.2 Test Equipment.....	15
5.2.3 Test Environment.....	17
5.3 Test case	17
5.3.1 Valid Behaviour (BV).....	18
5.3.2 Invalid Behaviour (BI).....	19
6 Test and Validation case studies	21
6.1 Introduction	21
6.2 Validation result of Data Hub in Daegu city	21
6.2.1 Interface	21
6.2.2 Data Model	23
6.3 Validation result of Data Hub in Siheung city.....	24
6.3.1 Interface	24
6.3.2 Data Model	27
7 Future Studies.....	28
7.1 Introduction	28
7.2 Requirement for Interoperability in Smart City Data	29
7.2.1 Data Unity for Data Sharing and Interoperability.....	29
7.2.2 Control Tower for Interoperability of Data.....	29
7.2.3 Integrated Management System from Creation to Disposal of Data.....	29
7.3 Guidelines for Securing Interoperability of Smart City Data	29

7.3.1	Establishment of Data Management System for Integrated Data Management.....	29
7.3.2	Establishing a Data Identification System through Global Uniqueness of City Data and Objects	30
7.3.3	Developing Governance for City Data System and Policy Establishment	31
7.4	Utilization of NGSI-LD for data interoperability	31
Annex A:	Change history	32
History		33

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) cross-cutting Context Information Management (CIM).

Modal verbs terminology

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1 Scope

The present document provides the case study about validation of NGSI-LD test platform and describe data interoperability in point of NGSI-LD interface. The case study describes how to develop the NGSI-LD interface and data model test platform. At the conclusion, the present document describe how the NGSI-LD test platform can be used for data interoperability in Smart city.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI GS CIM 009 (V1.6.1): "cross-cutting Context Information Management (CIM); NGSI-LD API".
 - [i.2] ETSI GS CIM 012 (V1.1.1): "Context Information Management (CIM); NGSI-LD Test Suite Structure".
 - [i.3] ETSI GS CIM 013: "Context Information Management (CIM); NGSI-LD Test Purposes Descriptions".
-

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

Data Model: model representing the structure of data stored and managed in a data hub, indicating the abstract model required during the access and processing of data

Data Model schema: specification that defines the data model utilized in a Data Hub, outlining the overall specifications for structuring and constraining data in order to objectify and load it into a database for utilization

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

API	Application Process Interface
ATS	Abstract Test Suite
BI	Invalid Behaviour tests
BV	Behaviour Valid tests
CCTV	Closed-Circuit Television
CPS	Cyber Physical System
GS1	Global Standard one
ICS	Implementation Conformance Statement
ID	Identity or Identifier
IUT	Implementation Under Test
IXIT	Implementation eXtra Information for Test
JSON	JavaScript Object Notation
KETI	Korea Electronics Technology Institution
NGSI-LD	Next Generation Service Interfaces Linked Data
QR	Quick Response code
RFID	Radio Frequency Identification
SUT	System - Under Test
TC	Test Case
TP	Test Purpose
TTA	Telecommunications Technology Association (South Korea)
URI	Unified Resource Identifier
URL	Uniform Ressource Locator

4 NGSI-LD Interface Test Validation

4.1 Introduction

Korea Electronics Technology Institute (KETI) developed a Data Hub by adopting ETSI GS CIM 009 [i.1]. Moreover, ETSI CIM developed a test framework and test suite that can test the NGSI-LD standard conformance and released a develop version of the test suite. The test suite is a development version and in order to apply it to the test equipment, it is necessary to secure the validity of the test operation, additional implementation, and validation of the implementation. This session introduces the process of establishing the test system such as the test scope, test equipment, and test environment, focusing on the interface functions supported by the Data Hub.

4.2 Test Environment

4.2.1 Implementation Under Test (IUT)

The smart city Data Hub divides logical functions into its modules and connects with each internal module or external service through the NGSI-LD interface to send request and responses to operations. Among the modules of the Data Hub, its core module stores smart city data based on the NGSI-LD information model and exchanges data between internal modules and external systems through the NGSI-LD interface. In this session, the data core module responsible for core functions in the Data Hub was defined as an IUT, and the interface conformance test was performed by adopting ETSI GS CIM 009 [i.1] and test framework. The Data core module includes a Context Broker supporting NGSI-LD interface and the Context Broker has a data structure based on the NGSI-LD information model. The Context Broker performs data modelling through context-based definitions of common terms.

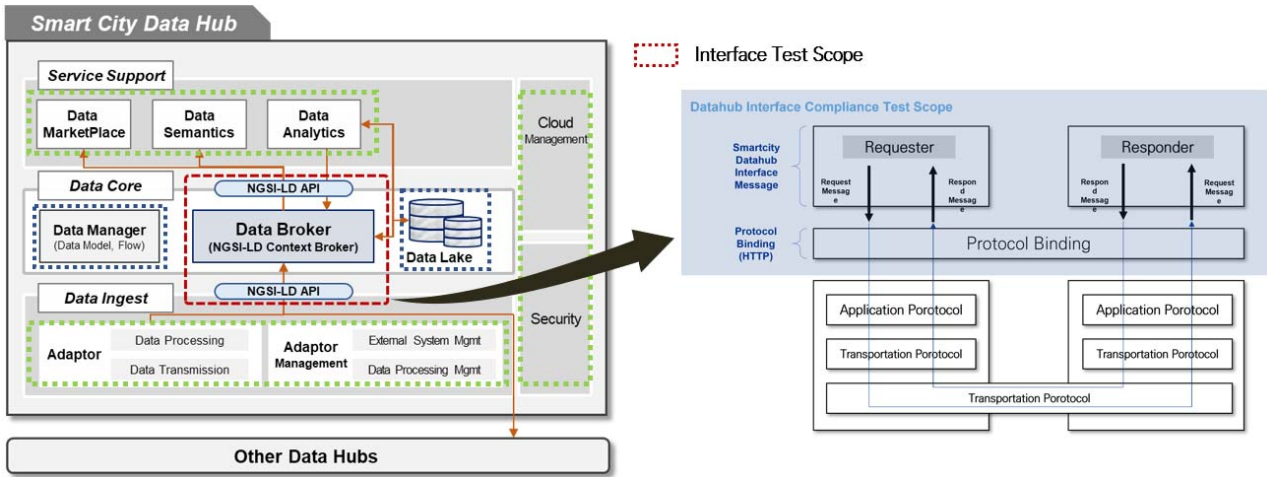


Figure 4.2.1-1: IUT system architecture for NGSI-LD interface test

4.2.2 Test Equipment

In order to set up Data Hub NGSI-LD interface conformance test, test equipment was developed based on technical specifications if required. The test equipment developed by complying with the standards defined by ETSI GS CIM 009 [i.1] and test framework has test procedures and criteria for each test case. The test equipment requests Create, retrieve, update, delete, and subscription operations for the data stored by the IUT, and the IUT returns a response message to the test equipment in response to the requested operation.

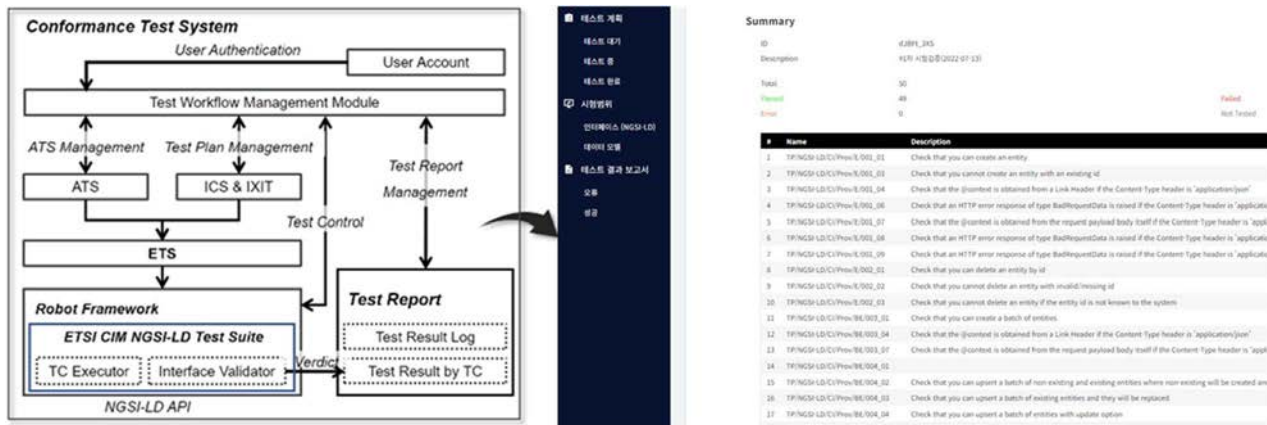


Figure 4.2.2-1: NGSI-LD Interface Test equipment

For the development of the test equipment, test cases were derived according to the interface functions supported by the Data Hub and the test suite was applied at the source code level. Figure 4.2.2-1 shows the system architecture and user interface of test equipment. The test equipment performs test planning, test execution, and test result reporting functions through the test manager and presents a PASS or Fail decision for test results for each test case in connection with the test suite of ETSI CIM. ETSI CIM's test suite runs in the robot framework environment, which is a test automation framework, and performs keyword-based test procedures. After that, it compares and analyses the response data returned from the IUT with the expected data to determine the test result.

4.2.3 Test Environment

The Data Hub NGSI-LD interface conformance test equipment serves as a requester that sends a message to the Data Hub under test according to the interface operation for each resource and the Data Hub operates as a responder. In addition, test equipment plays the role of context producer that provides resources to the context broker of Data Hub and context consumer that consumes resources.

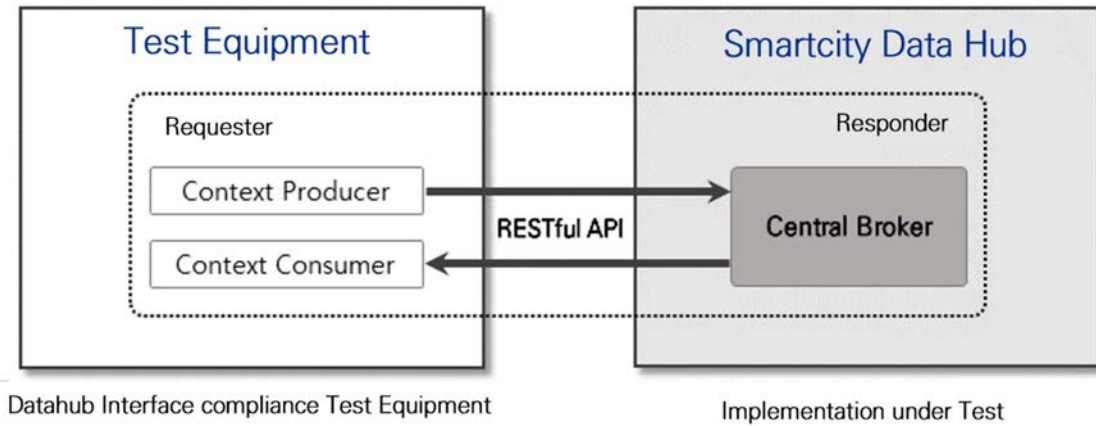


Figure 4.2.3-1: NGSI-LD interface test environment

4.2.4 Test case

For the Data Hub NGSI-LD interface test, figure 4.2.4-1 shows the test cases structure of ETSI GS CIM 012 [i.2] interface test. The test cases were classified according to the common service functions and resources of the IUT. Common service functions are divided into Provision and Consumption and each service function is divided into subtest groups according to the target resource.

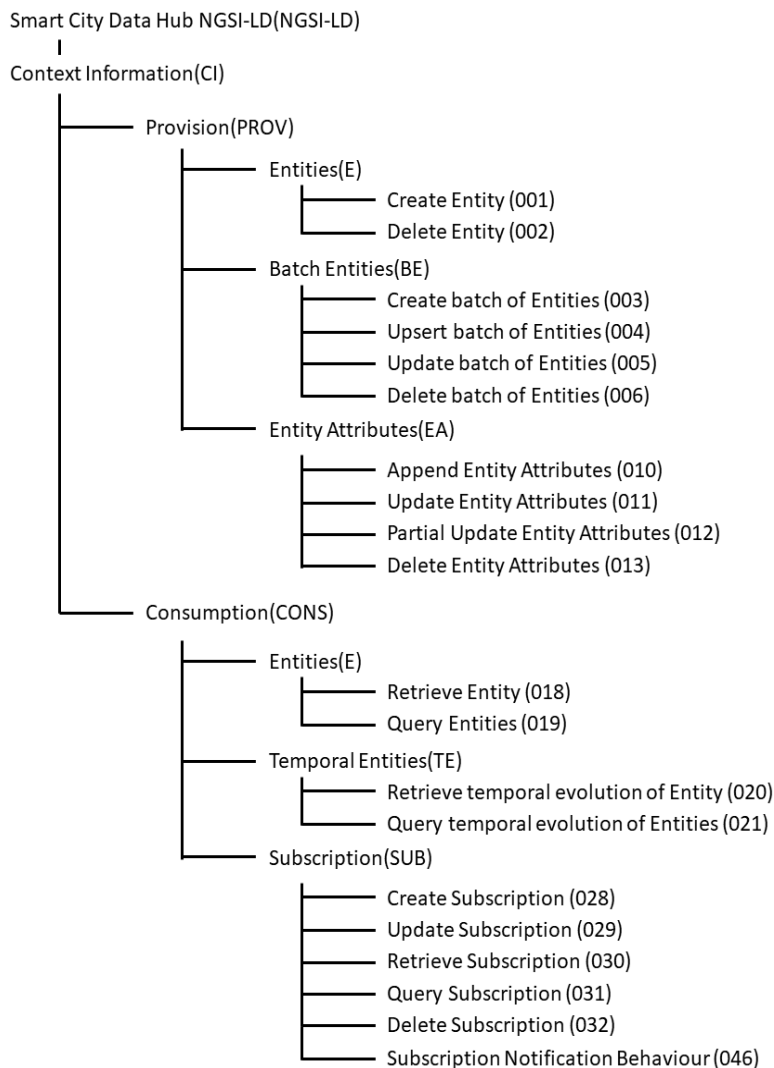


Figure 4.2.4-1: Test case structure for NGSI-LD interface

4.3 Update history about NGSI-LD interface test code

4.3.1 Introduction

TTA and KETI cooperated in the development of a Data Hub through an R&D project of the Republic of Korea. The role of TTA in this project was to develop a test system of the Data Hub's conformance to ETSI GS CIM 009 [i.1] and conduct tests to ensure the reliability of the Data Hub developed by KETI. To fulfil its role, TTA developed a test system as described above. As the purpose of developing the test system was to verify the conformance of the Data Hub to ETSI GS CIM 009 [i.1], as explained above, the NGSI-LD functions applied by the Data Hub were confirmed in advance to establish the test system.

Since the Data Hub did not apply all NGSI-LD functions, the test cases had to be designed according to the NGSI-LD functions supported by the Data Hub. Then, the test code of the test cases was downloaded from ETSI CIM git, and the code was validated to enhance the reliability of the test system. The Data Hub's NGSI-LD interface test system was developed through this process. However, the validation had the following limitations. First, the test code of test suite was a development version and not the official one. There are still some test cases which is not developed yet according to ETSI GS CIM 013 [i.3]. Therefore, using an incomplete test suite was the only way to establish the test system of the Data Hub.

In order to test the NGSI-LD interface of Data Hub, TTA developed the undeveloped test cases and updated the incorrect ones which were not run according to the standard. Second, there was a time limit on completing the test cases design for the NGSI-LD interface test. Due to the development speed of the Data Hub and the nature of R&D in Korea, there was a deadline for establishing the test system. Instead of reviewing all of the test cases distributed by ETSI CIM, the test cases for the functions supported by the Data Hub were selected, and TTA validated the test cases. Third, the test cases were designed around the functions supported by the Data Hub because the purpose of establishing the test system was to verify the conformance of the Data Hub. Therefore, TTA considered only the NGSI-LD function of the Data Hub for the test system and did not validate the other test cases. Regardless of the limitations above, validation of the NGSI-LD test code contributed to increasing the reliability of test suite.



Figure 4.3.1-1: Process for validation of NGSI-LD interface test equipment

4.3.2 Test cases Design

The test cases distributed by ETSI CIM consist of 277 cases. As described above, 76 test cases that can be used for the test were selected among the NGSI-LD functions supported by the Data Hub.

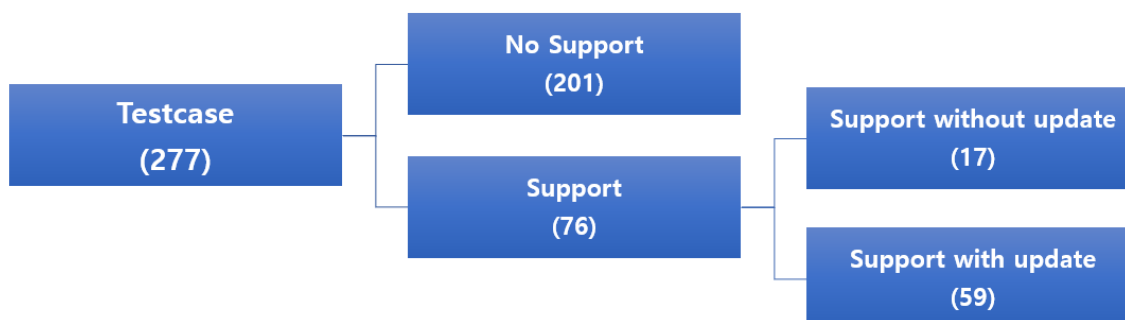


Figure 4.3.2-1: Supported Test cases of NGSI-LD Test Suite

4.3.3 Validation

It is necessary to install the Test Suite in the test equipment and check whether the test equipment operates correctly based on the test standards. This series of verification processes is called validation, and the Data Hub was used to validate the test equipment. Two validations are performed, and test standards are carefully reviewed to ensure that the Data Hub and test equipment operate correctly according to the Standards. At the same time, the scope of test verification is confirmed by checking whether the Data Hub supports the interface's operation for each test cases.

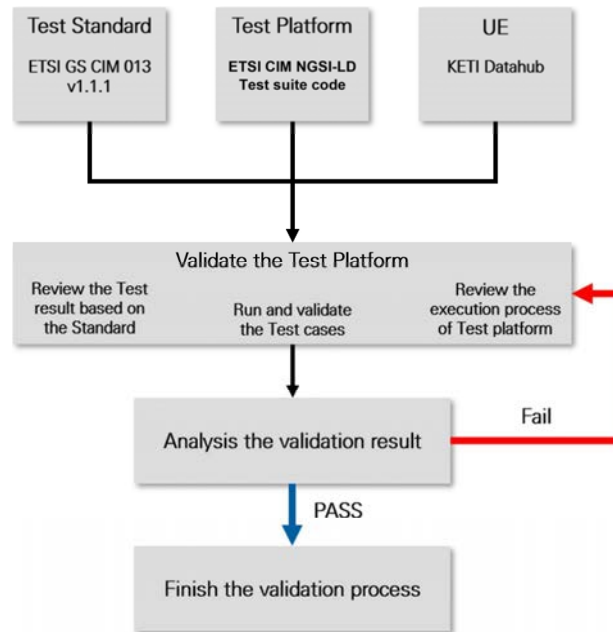


Figure 4.3.3-1: Validation Process of NGS-LD Test Suite

4.3.4 Validation Result

As shown in table 4.3.4-1, a total of 41 detailed test cases passed the first validation, and a total of 73 test cases passed the second validation. TTA conducted two NGS-LD interface conformance tests on Data Hub using the test equipment. Some of the test cases that failed in the first validation were corrected and supplemented. The correction and supplementation history are described in clause 4.3.5. Secondary validation was conducted for the corrected and supplemented test cases, and the validation result was derived based on the results. Through the validation process, it was confirmed that the Data Hub supports interface operations for a total of 73 test cases, and the scope of the interface conformance test was determined based on ETSI GS CIM 009 test framework using the validation results.

Table 4.3.4-1: Validation Result

NGSI-LD API Operation	Test cases	Case in Detail	Validation Result		
			First Validation	Second Validation	Support for Data Hub
Create Entity	TP/NGSI-LD/CI/Prov/E/001_01	01	FAIL	FAIL	NOT SUPPORT
		02	PASS	PASS	SUPPORT
		03	PASS	PASS	SUPPORT
		04	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_02	01	FAIL	FAIL	NOT SUPPORT
		02	FAIL	FAIL	NOT SUPPORT
		03	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_03	-	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_04	-	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_05	-	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_06	-	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/E/001_07	-	FAIL	PASS	SUPPORT
TP/NGSI-LD/CI/Prov/E/001_08	-	PASS	PASS	SUPPORT	
TP/NGSI-LD/CI/Prov/E/001_09	-	FAIL	PASS	SUPPORT	
Delete Entity	TP/NGSI-LD/CI/Prov/E/002_01	-	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/E/002_02	01	FAIL	FAIL	NOT SUPPORT
		02	PASS	PASS	SUPPORT
TP/NGSI-LD/CI/Prov/E/002_03	-	FAIL	PASS	SUPPORT	
Create batch of Entities	TP/NGSI-LD/CI/Prov/BE/003_01	01	FAIL	FAIL	NOT SUPPORT
		02	FAIL	PASS	SUPPORT
		03	FAIL	PASS	SUPPORT
		04	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/003_02	-	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/003_03	01	FAIL	FAIL	NOT SUPPORT
		02	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/003_04	-	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/003_05	-	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/003_06	-	FAIL	FAIL	NOT SUPPORT
TP/NGSI-LD/CI/Prov/BE/003_07	-	FAIL	PASS	SUPPORT	
TP/NGSI-LD/CI/Prov/BE/003_08	-	FAIL	FAIL	NOT SUPPORT	
TP/NGSI-LD/CI/Prov/BE/003_09	-	FAIL	FAIL	NOT SUPPORT	
Upsert batch of Entities	TP/NGSI-LD/CI/Prov/BE/004_01	01	FAIL	PASS	SUPPORT
		02	FAIL	PASS	SUPPORT
		03	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/004_02	01	FAIL	PASS	SUPPORT
		02	FAIL	PASS	SUPPORT
		03	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/004_03	01	PASS	PASS	SUPPORT
		02	PASS	PASS	SUPPORT
		03	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/004_04	01	FAIL	PASS	SUPPORT
		02	FAIL	PASS	SUPPORT
		03	FAIL	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/004_05	-	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/004_06	01	FAIL	FAIL	NOT SUPPORT
02		FAIL	FAIL	NOT SUPPORT	
Update batch of Entities	TP/NGSI-LD/CI/Prov/BE/005_01	01	PASS	PASS	SUPPORT
		02	PASS	PASS	SUPPORT
		03	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/005_02	01	PASS	PASS	SUPPORT
		02	PASS	PASS	SUPPORT
		03	FAIL	FAIL	NOT SUPPORT
	TP/NGSI-LD/CI/Prov/BE/005_03	-	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Prov/BE/005_04	01	FAIL	FAIL	NOT SUPPORT
02		FAIL	FAIL	NOT SUPPORT	

NGSI-LD API Operation	Test cases	Case in Detail	Validation Result				
			First Validation	Second Validation	Support for Data Hub		
Delete batch of Entities	TP/NGSI-LD/CI/Prov/BE/006_01	-	PASS	PASS	SUPPORT		
	TP/NGSI-LD/CI/Prov/BE/006_02	-	FAIL	PASS	SUPPORT		
	TP/NGSI-LD/CI/Prov/BE/006_03	01 02	FAIL FAIL	FAIL FAIL	NOT SUPPORT NOT SUPPORT		
Append Entity Attributes	TP/NGSI-LD/CI/Prov/EA/010_01	01 02	PASS FAIL	PASS FAIL	SUPPORT NOT SUPPORT		
	TP/NGSI-LD/CI/Prov/EA/010_02	01 02 03	FAIL PASS FAIL	FAIL PASS FAIL	NOT SUPPORT SUPPORT NOT SUPPORT		
	TP/NGSI-LD/CI/Prov/EA/010_03	-	FAIL	PASS	SUPPORT		
	Update Entity Attributes	TP/NGSI-LD/CI/Prov/EA/011_01	01 03	PASS FAIL	PASS FAIL	SUPPORT NOT SUPPORT	
		TP/NGSI-LD/CI/Prov/EA/011_02	01 02 03	FAIL PASS FAIL	FAIL PASS FAIL	NOT SUPPORT SUPPORT NOT SUPPORT	
TP/NGSI-LD/CI/Prov/EA/011_03		-	FAIL	PASS	SUPPORT		
Partial Update Entity Attributes		TP/NGSI-LD/CI/Prov/EA/012_01	01	PASS	PASS	SUPPORT	
	TP/NGSI-LD/CI/Prov/EA/012_02	01 02 03 04 05 06	FAIL PASS PASS PASS PASS PASS	FAIL PASS PASS FAIL PASS PASS	NOT SUPPORT SUPPORT SUPPORT NOT SUPPORT SUPPORT SUPPORT		
		TP/NGSI-LD/CI/Prov/EA/012_03	01 04	FAIL FAIL	PASS FAIL	SUPPORT NOT SUPPORT	
		Delete Entity Attributes	TP/NGSI-LD/CI/Prov/EA/013_01	01 03	FAIL FAIL	FAIL FAIL	NOT SUPPORT NOT SUPPORT
			TP/NGSI-LD/CI/Prov/EA/013_02	01 02 03	FAIL PASS FAIL	FAIL PASS FAIL	NOT SUPPORT SUPPORT NOT SUPPORT
			TP/NGSI-LD/CI/Prov/EA/013_03	01 02	FAIL FAIL	PASS FAIL	SUPPORT NOT SUPPORT
	Retrieve Entity		TP/NGSI-LD/CI/Cons/E/018_01	01 02 03	PASS PASS PASS	PASS PASS PASS	SUPPORT SUPPORT SUPPORT
TP/NGSI-LD/CI/Cons/E/018_02			01 02	FAIL FAIL	FAIL PASS	NOT SUPPORT SUPPORT	
TP/NGSI-LD/CI/Cons/E/018_03			01 02	PASS PASS	PASS PASS	SUPPORT SUPPORT	
TP/NGSI-LD/CI/Cons/E/018_04		-	PASS	PASS	SUPPORT		
TP/NGSI-LD/CI/Cons/E/018_06		01 02	PASS PASS	PASS PASS	SUPPORT SUPPORT		
Query Entities		TP/NGSI-LD/CI/Cons/E/019_01	01 02 03 04 05	FAIL FAIL FAIL PASS FAIL	FAIL FAIL FAIL PASS FAIL	NOT SUPPORT NOT SUPPORT NOT SUPPORT SUPPORT NOT SUPPORT	
			TP/NGSI-LD/CI/Cons/E/019_03	01 02 03 04 05	FAIL PASS FAIL FAIL PASS	PASS PASS FAIL PASS PASS	SUPPORT SUPPORT NOT SUPPORT SUPPORT SUPPORT
			TP/NGSI-LD/CI/Cons/E/019_04	-	PASS	PASS	SUPPORT
	TP/NGSI-LD/CI/Cons/E/019_06		-	FAIL	FAIL	NOT SUPPORT	
	Retrieve Available Entity Types		TP/NGSI-LD/CI/CONS/DISC/022_01	01 02	PASS PASS	PASS PASS	SUPPORT SUPPORT
		Retrieve Details of Available Entity Types	TP/NGSI-LD/CI/CONS/DISC/023_01	01 02	FAIL FAIL	PASS PASS	SUPPORT SUPPORT
	Create Subscription	TP/NGSI-LD/CI/SUB/028_03	-	FAIL	PASS	SUPPORT	
	Update Subscription	TP/NGSI-LD/CI/SUB/029_05	-	FAIL	PASS	SUPPORT	
	Retrieve Subscription	TP/NGSI-LD/CI/SUB/030_03	-	FAIL	PASS	SUPPORT	
	Delete Subscription	TP/NGSI-LD/CI/SUB/032_03	-	FAIL	PASS	SUPPORT	

4.3.5 Update History

4.3.5.0 Introduction

As a result of installing the Test Suite in the test equipment and conducting validation, several FAIL issues occurred. Generally, four issues were found, for which updates were performed. The first issue is that the test procedure of the test case covers a wider scope than the test purpose. In other words, although the purpose of the test was achieved in the test procedure, some test cases were failed because they have additional test procedure unrelated to the test purpose. In the test code, there are two Retrieve requests, one is Retrieve with context and the other is Retrieve without context. The test equipment always determines failure because the IUT's response is either with or without context, so it is not possible to satisfy both conditions. To solve this problem, the issued test cases were modified by deleting the additional Retrieve request without context in the test suite code. Secondly, it was found that some test procedures did not adhere to the technical specifications and consequently failed to obtain the expected test results. According to ETSI GS CIM 009 [i.1], datasetid is not mandatory when retrieving for entities. However, but test suite was developed to make sure the datasetid is a match when retrieving for entities, making it operate differently from the actual test purpose. As the result, the part that checks the datasetid was deleted. Third, the source code of the test suite was not developed according to the Test Standards. The test was not performed according to the intended test procedure, and it was modified according to the test standard to ensure proper operation.

4.3.5.1 Deletion of Unnecessary Retrieve Request for Test Purpose

Table 4.3.5.1-1: Update history about deletion of Retrieve Request

Target Test case	TP/NGSI-LD/CI/Prov/E/001_04 TP/NGSI-LD/CI/Prov/E/001_07 TP/NGSI-LD/CI/Prov/BE/003_04 TP/NGSI-LD/CI/Prov/BE/003_07
Issues	There were test cases where the test case failed the test due to additional test procedures even though it fulfilled the test goal and passed.
Details of Modification	Delete the additional Retrieve request without context in the Test Suite code.

4.3.5.2 datasetid

Table 4.3.5.2-1: Update history about datasetid

Target Test case	TP/NGSI-LD/CI/Prov/EA/010_01 TP/NGSI-LD/CI/Prov/EA/010_02 TP/NGSI-LD/CI/Prov/EA/011_01 TP/NGSI-LD/CI/Prov/EA/012_01 TP/NGSI-LD/CI/Prov/EA/012_02 TP/NGSI-LD/CI/Prov/EA/013_02 TP/NGSI-LD/CI/Prov/EA/013_03
Issues	The test equipment retrieved for datasetid although datasetid is not essential regarding technical standards.
Details of Modification	Remove the part where the test equipment requires to retrieve datasetid so that the datasetid does not affect to the test verdict.

4.3.5.3 Mismatch between Test Standards and Test equipment

Table 4.3.5.3-1: Update history about mismatch between standard and equipment

Target Test case	TP/NGSI-LD/CI/SUB/028_03
Issues	Test standards and the source code developed based on them are different from the results expected from test results. Modified the source code based on test standards.
Details of Modification	Modified "Check Response Status Code Set to 200".

5 NGSI-LD based Data Model Test Validation

5.1 Introduction

This clause explains how to test and validate the data model conformance of the Data Hub using NGSI-LD. A data model represents the structure of data stored and managed in the Data Hub. It is necessary to use a unified data model to ensure data interoperability between the various smart city platforms. Even when the same data model is used, the data platform might generate data according to its own way. In order to test the ability of generating data according to the data model, the data model conformance test was developed using the NGSI-LD interface.

5.2 Test Environment

5.2.1 Implementation Under Test

The data model stored and managed based on the Data Hub schema is defined as a test target, and the data model can be exchanged with internal and external systems through the Central Broker supporting NGSI-LD-based interface.

5.2.2 Test Equipment

The test equipment is a Robot Framework-based test equipment verification software. It drives the validation module based on user management for the IUT, System Under Test (SUT) management, test cases management, test execution control, and test report management functions. The verification module interprets the test information, executes pre-processing, test execution, and post-processing according to the test scenario, and judges the test results. The configuration of the test equipment system is as shown in figure 5.2.2-1.

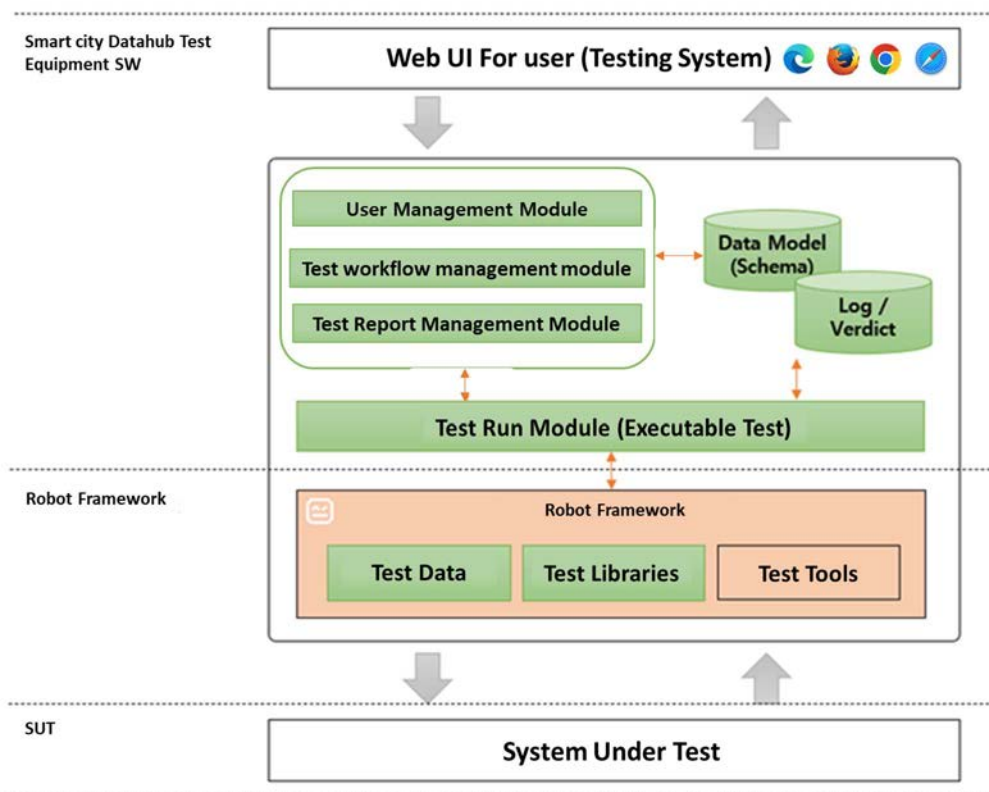


Figure 5.2.2-1: System architecture of Data model test equipment

The test equipment that tests the conformance of the data model uses the NGSI-LD interface to send data Create and Retrieve requests to the IUT according to the data model and confirms whether the data is created according to the data model. For this, the schema file of the data model and the function to manage the file are required to proceed with the test. Also, it is necessary to create and manage test data to test the data model. The data operate according to the test procedure through the test tool and library in the robot framework, and the test equipment automatically creates a test report based on the test result and log.

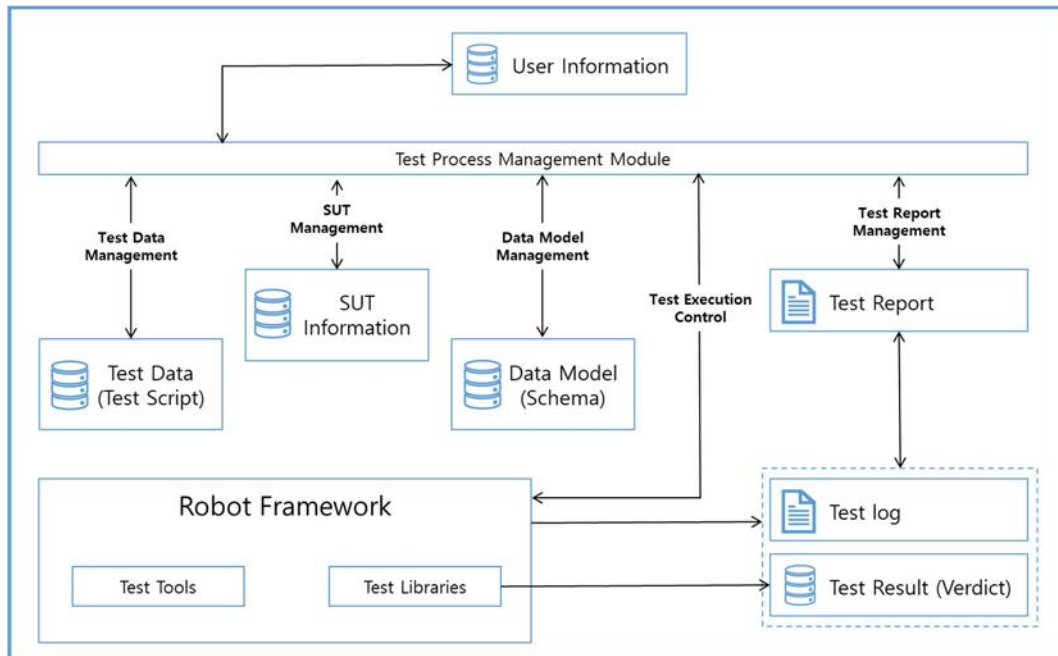


Figure 5.2.2-2: Process of Data Model test equipment

The operation of the test equipment provides user management for standard conformance test, System Under Test (SUT) management, data model schema registration, test cases management, test execution control, and test report management functions to utilize the test environment for the module to be tested and supports test related operations ranging from the test execution and the preparation of the test result report. The conformance test workflow of the test equipment is as shown in figure 5.2.2-3.

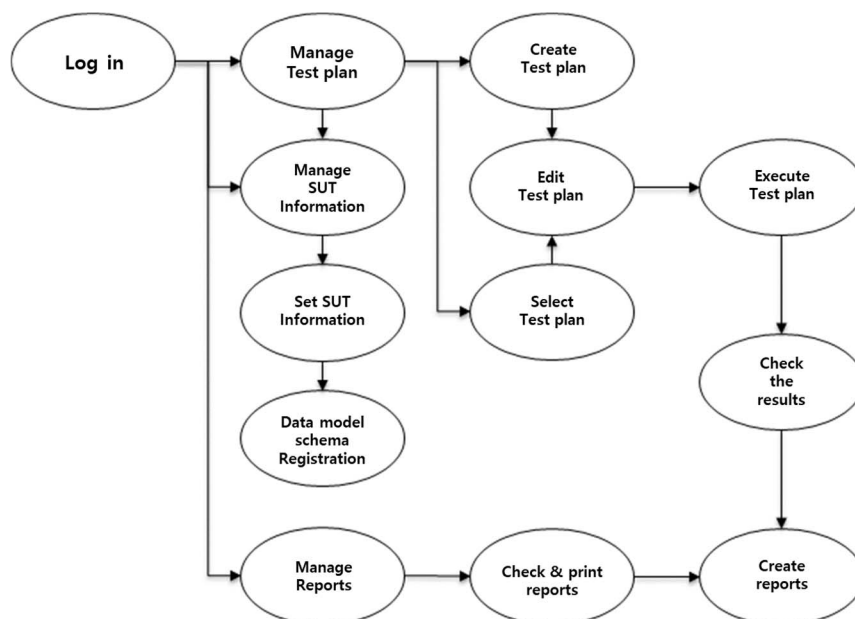


Figure 5.2.2-3: Decision process of Data model test equipment

The test equipment performs the process shown in figure 5.2.2-4 to test the data model. First, the JSON Schema file of the data model is uploaded to the test equipment to determine whether or not there is a syntax error in the JSON Schema file. Then, if there are no syntax errors, data for expectation data and sending the creation request are created through Test Data Generation. Expectation data serves as a list of correct answers to check whether the test equipment created the data model as specified in the schema by retrieving for entities created by the creation request sent to the IUT. Request data is created using the JSON schema file of the data model, and the test equipment sends a request message to the IUT to create an entity. Then, the test equipment transmits a message to retrieve the entity created by the IUT. The IUT compares the previously created expectation data with the entity that was retrieved to ensure that the IUT created the entity according to the JSON Schema of the data model.

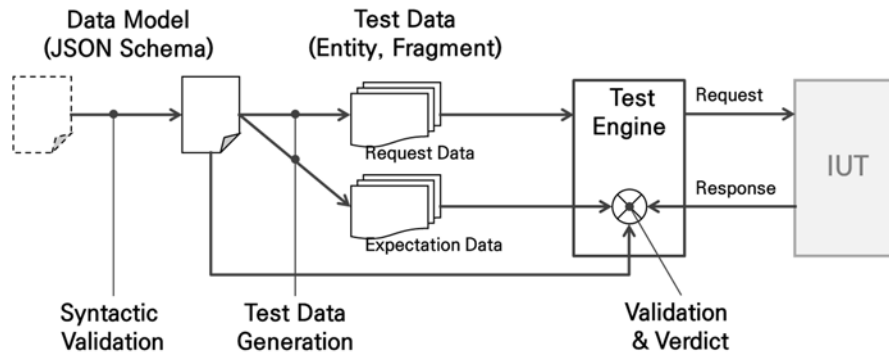


Figure 5.2.2-4: Test process of Data model equipment

5.2.3 Test Environment

The data model conformance test equipment supports storing and managing the data model of the IUT based on the schema. It also includes the Context Producer function to create and update data and the Context Consumer function to inquire about and subscribe to data. Through this function, the data model of the smart city Data Hub under test can be exchanged through the Central Broker. The data model Data Hub conformance test verifies whether the IUT transmits a response message that conforms to technical specifications for the request message from the test equipment as shown in figure 5.2.3-1.

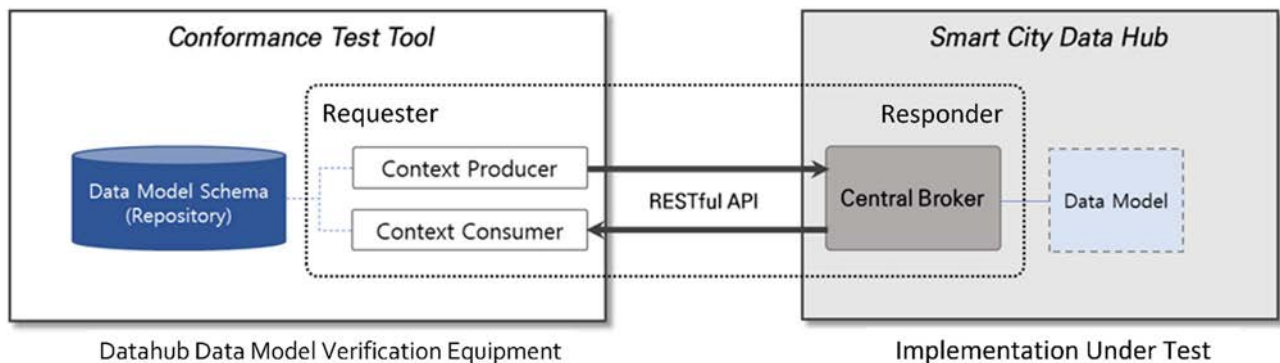


Figure 5.2.3-1: Test environment of Data model test

5.3 Test case

The test cases list is classified into a valid behaviour test and a behaviour test. The valid behaviour test consists of test cases for verifying the normal behaviour of the supported interface of the IUT, and the invalid behaviour test consists of test cases used to request an interface behaviour not supported by the IUT and to verify whether errors are handled for the request. In addition, reference identifiers are defined so that the interface defined in ETSI GS CIM 009 [i.1] can be referred to for each test cases. Tables 5.3.1-1 and 5.3.2-1 show the valid operation test cases list and the invalid operation test cases list, respectively.

5.3.1 Valid Behaviour (BV)

Table 5.3.1-1: Valid behaviour about Data Model test

Test Set	Operation	Test Purpose	Test cases
Data Core Module	Create Resource (CREATE)	Checks whether a response message 2001 (CREATED) is sent when the creation of an entity is requested.	TC/SCDH/COR/RES/CRE/BV-01
		Checks whether a response message 2001 (CREATED) is sent when the creation of an entity is requested.	TC/SCDH/COR/RES/CRE/BV-02
	Retrieve Resource (RETRIEVE)	Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry with an entity type is requested.	TC/SCDH/COR/RES/RET/BV-01
		Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry of a specific entity is requested.	TC/SCDH/COR/RES/RET/BV-02
		Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry is requested with the attribute name of a specific entity.	TC/SCDH/COR/RES/RET/BV-03
		Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry of history data with the entity type is requested.	TC/SCDH/COR/RES/RET/BV-04
		Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry of history data of a specific entity is requested.	TC/SCDH/COR/RES/RET/BV-05
		Checks whether a response message 2000 (OK) and corresponding data are sent when an inquiry of history data matching a specific entity's time is requested.	TC/SCDH/COR/RES/RET/BV-06
	Update Resource (UPDATE)	Checks whether a response message 2004 (CHANGED) is sent when the update of all attributes of a specific entity is requested.	TC/SCDH/COR/RES/UPD/BV-01
		Checks whether a response message 2004 (CHANGED) is sent when the update of a single attribute of a specific entity is requested.	TC/SCDH/COR/RES/UPD/BV-02
	Delete Resource (DELETE)	Checks whether a response message 2002 (DELETED) is sent when the deletion of a specific entity is requested.	TC/SCDH/COR/RES/DEL/BV-01
		Checks whether a response message 2002 (DELETED) is sent when the deletion of a single attribute of a specific entity is requested.	TC/SCDH/COR/RES/DEL/BV-02

5.3.2 Invalid Behaviour (BI)

Table 5.3.2-1: Invalid behaviour about Data Model test

Test Set	Operation	Test Purpose	Test cases
Data Core Module	Create Resource (CREATE)	Checks whether an error response message 4100 (ALREADY EXISTS) is sent when the creation of an entity is requested redundantly.	TC/SCDH/COR/RES/CRE/BI-01
		Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when the creation of an entity is requested without an essential parameter (ID).	TC/SCDH/COR/RES/CRE/BI-02
		Checks whether an error response message 4102 (INVALID PARAMETER TYPE) is sent when the creation of an entity is requested with a wrong parameter type.	TC/SCDH/COR/RES/CRE/BI-03
		Checks whether an error response message 4004 (NOT FOUND) is sent when the creation of an attribute of a deleted entity is requested.	TC/SCDH/COR/RES/CRE/BI-04
		Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when the creation of an attribute of an entity missing an essential parameter (TYPE) is requested.	TC/SCDH/COR/RES/CRE/BI-05
		Checks whether an error response message 4102 (INVALID PARAMETER TYPE) is sent when the creation of an attribute of an entity that includes a wrong parameter type is requested.	TC/SCDH/COR/RES/CRE/BI-06
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when unsupported action (CREATE) for the entity is requested.	TC/SCDH/COR/RES/CRE/BI-07
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when unsupported action (CREATE) for the entity's history data is requested.	TC/SCDH/COR/RES/CRE/BI-08
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when unsupported action (CREATE) for a specific entity's history data is requested.	TC/SCDH/COR/RES/CRE/BI-09
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (CREATE) for a specific entity attribute is requested.	TC/SCDH/COR/RES/CRE/BI-10
	Retrieve Resource (RETRIEVE)	Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when an inquiry about an entity missing an essential parameter (QUERY) is requested.	TC/SCDH/COR/RES/RET/BI-02
		Checks whether an error response message 4004 (NOT FOUND) is sent when an inquiry about a non-existing entity is requested.	TC/SCDH/COR/RES/RET/BI-03
		Checks whether an error response message 4004 (NOT FOUND) is sent when an inquiry about a non-existing entity attribute is requested.	TC/SCDH/COR/RES/RET/BI-04
		Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when an inquiry about history data missing an essential parameter (QUERY) is requested.	TC/SCDH/COR/RES/RET/BI-06
		Checks whether an error response message 4004 (NOT FOUND) is sent when an inquiry about the history data of a non-existing entity is requested.	TC/SCDH/COR/RES/RET/BI-07
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (RETRIEVE) for the attributes of multiple entities is requested.	TC/SCDH/COR/RES/RET/BI-08

Test Set	Operation	Test Purpose	Test cases
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (RETRIEVE) for an entity's specific attribute is requested.	TC/SCDH/COR/RES/RET/BI-09
	Update Resource (UPDATE)	Checks whether an error response message 4004 (NOT FOUND) is sent when the update of all attributes of a non-existing entity is requested.	TC/SCDH/COR/RES/UPD/BI-01
		Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when the update of all attributes missing an essential parameter (TYPE) is requested.	TC/SCDH/COR/RES/UPD/BI-02
		Checks whether an error response message 4102 (INVALID PARAMETER TYPE) is sent when the update of all attributes that include a wrong parameter type is requested.	TC/SCDH/COR/RES/UPD/BI-03
		Checks whether an error response message 4004 (NOT FOUND) is sent when the update of a specific entity's single non existing attribute is requested.	TC/SCDH/COR/RES/UPD/BI-04
		Checks whether an error response message 4101 (MANDATORY PARAMETER MISSING) is sent when the update of a single attribute missing an essential parameter is requested.	TC/SCDH/COR/RES/UPD/BI-05
		Checks whether an error response message 4102 (INVALID PARAMETER TYPE) is sent when the update of an attribute that includes a wrong parameter type is requested.	TC/SCDH/COR/RES/UPD/BI-06
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (UPDATE) for an entity is requested.	TC/SCDH/COR/RES/UPD/BI-07
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (UPDATE) for an entity is requested.	TC/SCDH/COR/RES/UPD/BI-08
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (UPDATE) for an entity's history data is requested.	TC/SCDH/COR/RES/UPD/BI-09
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (UPDATE) for an entity's history data is requested.	TC/SCDH/COR/RES/UPD/BI-10
	Delete Resource (DELETE)	Checks whether an error response message 4004 (NOT FOUND) is sent when the deletion of a specific non existing entity is requested.	TC/SCDH/COR/RES/DEL/BI-01
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when unsupported action (DELETE) for an entity is requested.	TC/SCDH/COR/RES/DEL/BI-02
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (DELETE) for an entity attribute is requested.	TC/SCDH/COR/RES/DEL/BI-03
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when an unsupported action (DELETE) for an entity's history data is requested.	TC/SCDH/COR/RES/DEL/BI-04
		Checks whether an error response message 4005 (METHOD NOT ALLOWED) is sent when unsupported action (DELETE) for a specific entity's history data is requested.	TC/SCDH/COR/RES/DEL/BI-05

6 Test and Validation case studies

6.1 Introduction

Clause 6 describes the case of test verification conducted on Data Hub in KETI, Daegu, and Siheung through R&D projects in South Korea. Test cases and test equipment were provided for the Data Hub developed through the R&D projects to the services offered by KETI, Daegu, and Siheung. The interface and data model compatibility of the Data Hub was tested, and the results are explained in clause 6.

6.2 Validation result of Data Hub in Daegu city

6.2.1 Interface

Table 6.2.1-1: <Validation result of NGSi-LD interface in Daegu city>

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Prov/E/001_01	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
	04	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_06	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_07	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_08	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_09	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_01	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/003_01	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
	04	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/003_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/003_07	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/004_01	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/004_02	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/004_03	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/004_04	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/005_01	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/005_02	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/005_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/006_01	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/006_02	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/010_01	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/010_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/010_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/011_01	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/011_02	02	PASS	PASS	N/A

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Prov/EA/011_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/012_01	01	FAIL	PASS	When partial update is requested using valid data, IUT returned 400 response code, determined it as FAIL.
TP/NGSI-LD/CI/Prov/EA/012_02	02	PASS	PASS	N/A
	03	FAIL	PASS	When partial update is requested using invalid data, IUT returned 500 response code, determined it as FAIL.
	05	PASS	PASS	N/A
	06	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/012_03	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/013_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/013_03	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_01	01	FAIL	PASS	The value of @context variable within the entity creation request payload is different from @context within the Retrieve response payload, handled as FAIL.
	02	FAIL	PASS	Same as above.
	03	FAIL	PASS	Same as above.
TP/NGSI-LD/CI/Cons/E/018_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_03	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_04	01	FAIL	PASS	The value of @context variable within the entity creation request payload is different from @context within the Retrieve response payload, handled as FAIL.
TP/NGSI-LD/CI/Cons/E/018_06	01	FAIL	PASS	The value of @context variable within the entity creation request payload is different from @context within the Retrieve response payload, handled as FAIL.
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/019_01	04	FAIL	PASS	The entity attribute value for the entity creation request is different from Retrieve request, the attribute value within the response payload returned by the IUT, handled as FAIL.
TP/NGSI-LD/CI/Cons/E/019_03	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	04	PASS	PASS	N/A
	05	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/019_04	-	FAIL	PASS	The value of @context variable within the entity creation request payload is different from @context within the Retrieve response payload, handled as FAIL.
TP/NGSI-LD/CI/Cons/DISC/022_01	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/DISC/023_01	01	FAIL	PASS	In the entity type search result, the term for "location" attribute is expressed in Full URL, handled as FAIL.
	02	FAIL	PASS	
TP/NGSI-LD/CI/Cons/SUB/028_03	-	FAIL	PASS	

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Cons/SUB/029_05	-	FAIL	PASS	In the subscription update result, "status" attribute within the response result payload, returned for retrieve, is not returned, handled as FAIL.
TP/NGSI-LD/CI/Cons/SUB/030_03	-	FAIL	PASS	In the subscription update result, "isActive" attribute in the response result returned from the IUT is added, handled as FAIL.
TP/NGSI-LD/CI/Cons/SUB/032_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/046_01	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/046_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/046_09	-	PASS	PASS	N/A

6.2.2 Data Model

Table 6.2.2-1: <Validation result of Data Model in Daegu city>

Test case	Test case Detail	Validation Result by Data Model			Remarks
		accident_fire_mobile_app		flood_manhole_precipitation	
		Technical Support	First Validation	First Validation	
TC/SCDH/DM/RES/CR/BV-01	02	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BV-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BV-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-01	01	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BV-01	01	PASS	PASS	PASS	N/A
	02	Not Supported	Not Supported	Not Supported	IUT does not support "unitCode" attribute of the validation data model specification (schema file).
TC/SCDH/DM/RES/CA/BV-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BV-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BI-01	01	FAIL	PASS	PASS	When append is requested with an attribute having invalid data, the IUT handled it as a string and returned the code 204 regardless of the data type requested.
	02	Not Supported	Not Supported	Not Supported	IUT does not support "unitCode" attribute of the validation data model specification (schema file).
TC/SCDH/DM/RES/CA/BI-02	-	FAIL	PASS	PASS	When append is requested with an attribute having invalid data, the IUT handled it as a string and returned the code 204 regardless of the data type requested.
TC/SCDH/DM/RES/CA/BI-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CU/BV-01	01	PASS	PASS	PASS	N/A
	02	Not Supported	Not Supported	Not Supported	IUT does not support "unitCode" attribute of the validation data model specification (schema file).
TC/SCDH/DM/RES/CU/BV-02	-	PASS	PASS	PASS	N/A

Test case	Test case Detail	Validation Result by Data Model			Remarks
		accident_fire_mobile_app		flood_manhole_precipitation	
		Technical Support	First Validation	First Validation	
TC/SCDH/DM/RES/CU/BV-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CU/BI-01	01	PASS	PASS	PASS	N/A
	02	Not Supported	Not Supported	Not Supported	IUT does not support "unitCode" attribute of the validation data model specification (schema file).
TC/SCDH/DM/RES/CU/BI-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CU/BI-03	-	PASS	PASS	PASS	N/A

6.3 Validation result of Data Hub in Siheung city

6.3.1 Interface

Table 6.3.1-1: <Validation result of NGS-LD interface in Siheung city>

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Prov/E/001_01	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
	04	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_06	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_07	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_08	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/001_09	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_01	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/E/002_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/003_01	02	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	03	PASS	PASS	N/A
	04	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/003_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/003_07	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/004_01	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	PASS	PASS	N/A
	03	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Prov/BE/004_02	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	PASS	PASS	N/A
	03	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/004_03	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	PASS	PASS	N/A
	03	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/004_04	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	PASS	PASS	N/A
	03	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/005_01	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/005_02	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
	02	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/005_03	-	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/BE/006_01	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/BE/006_02	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/010_01	01	FAIL	PASS	The expression (Time Zone format) for the time attribute (observedAt) was incorrect regarding Retrieve response, handling it as FAIL.
TP/NGSI-LD/CI/Prov/EA/010_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/010_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/011_01	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/011_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/011_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/012_01	01	PASS	PASS	N/A

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Prov/EA/012_02	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
	05	PASS	PASS	N/A
	06	FAIL	FAIL	When the partial update of invalid Entity Attribute (Empty) was requested, the IUT returned 204 (No Content) response code.
TP/NGSI-LD/CI/Prov/EA/012_03	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/013_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Prov/EA/013_03	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_01	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	03	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_02	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_03	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_04	01	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/018_06	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/019_01	04	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/019_03	01	PASS	PASS	N/A
	02	PASS	PASS	N/A
	04	PASS	PASS	N/A
	05	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/E/019_04	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/DISC/022_01	01	FAIL	PASS	The response to Entity Type Retrieve request does not match the Expectation Data (CCTV, OffStreetParking).
	02	FAIL	PASS	The response to Entity Type Retrieve request does not match the Expectation Data (CCTV, OffStreetParking).
TP/NGSI-LD/CI/Cons/DISC/023_01	01	FAIL	FAIL	For Vehicle Entity creation request, returned the error message for Provided By attribute and 400 response code, failing to create an Entity. The response to Entity Type Retrieve request does not match the Expectation Data (CCTV, OffStreetParking).
	02	FAIL	FAIL	For Vehicle Entity creation request, returned the error message for Provided By attribute and 400 response code, failing to create an Entity. The response to Entity Type Retrieve request does not match the Expectation Data (CCTV, OffStreetParking).
TP/NGSI-LD/CI/Cons/SUB/028_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/029_05	-	FAIL	FAIL	Data model name in full URL is expected as the return to the Retrieve request missing Link Header; however, IUT returns Short Name, handled as FAIL.
TP/NGSI-LD/CI/Cons/SUB/030_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/032_03	-	PASS	PASS	N/A
TP/NGSI-LD/CI/Cons/SUB/046_01	-	FAIL	PASS	Notify message should be returned after successfully changing Entity attribute, the IUT did not return Notify message, handled as FAIL.

Test case	Test case Detail	Result of Technical Support (PASS/FAIL)	First Validation Result (PASS/FAIL)	Remarks
TP/NGSI-LD/CI/Cons/SUB/046_04	-	FAIL	PASS	Notify message should be returned after successfully changing Entity attribute, the IUT did not return Notify message, handled as FAIL.
TP/NGSI-LD/CI/Cons/SUB/046_09	-	FAIL	PASS	Notify message should be returned after successfully changing Entity attribute, the IUT did not return Notify message, handled as FAIL.

6.3.2 Data Model

Table 6.3.2-1: <Validation result of Data Model in Siheung city>

Test case	Test case Detail	Validation Result by Data Model			Remarks
		AirQuality Measurement	Building EnergyUsage	Health Measurement	
TC/SCDH/DM/RES/CR/BV-01	02	FAIL	FAIL	FAIL	The IUT successfully created an entity, however, not according to the schema specification. Handled as FAIL.
TC/SCDH/DM/RES/CR/BV-02	-	FAIL	FAIL	FAIL	The IUT successfully created an entity, however, not according to the schema specification. Handled as FAIL.
TC/SCDH/DM/RES/CR/BV-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-01	01	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CR/BI-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BV-01	01	FAIL	FAIL	FAIL	The IUT successfully added an entity, however, not according to the schema. Handled as FAIL.
	02	Not Supported	Not Supported	Not Supported	Does not support "unitCode" attribute of the validation data model specification (schema file) with the selected test case.
TC/SCDH/DM/RES/CA/BV-02	-	FAIL	FAIL	FAIL	The IUT successfully added an entity, however, not according to the schema. Handled as FAIL.
TC/SCDH/DM/RES/CA/BV-03	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BI-01	01	PASS	PASS	PASS	N/A
	02	Not Supported	Not Supported	Not Supported	Does not support "unitCode" attribute of the validation data model specification (schema file) with the selected test case.
TC/SCDH/DM/RES/CA/BI-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CA/BI-03	-	PASS	PASS	PASS	N/A

Test case	Test case Detail	Validation Result by Data Model			Remarks
		AirQuality Measurement	Building EnergyUsage	Health Measurement	
TC/SCDH/DM/RES/CU/BV-01	01	FAIL	FAIL	FAIL	The IUT successfully added an entity, however, not according to the schema. Handled as FAIL.
	02	Not Supported	Not Supported	Not Supported	Does not support "unitCode" attribute of the validation data model specification (schema file) with the selected test case.
TC/SCDH/DM/RES/CU/BV-02	-	FAIL	FAIL	FAIL	The IUT successfully added an entity, however, not according to the schema. Handled as FAIL.
TC/SCDH/DM/RES/CU/BV-03	-	FAIL	FAIL	FAIL	The IUT successfully added an entity, however, not according to the schema. Handled as FAIL.
TC/SCDH/DM/RES/CU/BI-01	01	PASS	PASS	PASS	N/A
	02	Not Supported	Not Supported	Not Supported	Does not support "unitCode" attribute of the validation data model specification (schema file) with the selected test case.
TC/SCDH/DM/RES/CU/BI-02	-	PASS	PASS	PASS	N/A
TC/SCDH/DM/RES/CU/BI-03	-	PASS	PASS	PASS	N/A

7 Future Studies

7.1 Introduction

Due to the development of information and communication technology, cutting-edge technologies such as CPS (Cyber Physical System), digital twin, and metaverse were developed, and various services are being provided in our life. As technology advances, it is imperative to establish a system and policy that can systematically manage and utilize data generated from numerous services. However, interoperability of data between different services cannot be guaranteed due to the absence of metadata, management system, and identification system. Therefore, data interoperability is essential to support the urban services because various services can affect each other.

Data interoperability can be secured through the data management system, identification system, and metadata definition. First, in order to define the data management system, essential functions for data management were defined considering the life cycle characteristics and data governance aspects. second, the metadata need to be defined using data from representative services currently being used in the city. The metadata helps understand data across different services through data description. Third, as for the data identification system, GS1, which is an international standard, can be used for interoperability. The data identification system helps to provide data interoperability between different services by providing unique data. Although this study is insufficient to secure interoperability of all data, it can be used as basic research to secure minimum data interoperability, and standardization and policy establishment should be carried out for future data interoperability.

7.2 Requirement for Interoperability in Smart City Data

7.2.1 Data Unity for Data Sharing and Interoperability

In order to support data interoperability between various services, it is necessary to identify various types of data and objects in the city. Due to the advancement of information and communication, it is possible to secure data interoperability by facilitating data search and sharing in order to share data between various platforms. For this, since monitoring and controlling objects represented by city data is necessary, it is essential to identify each data and object represented by a set of data. In addition, it is necessary to consider data interoperability that can be applied globally, rather than being limited to specific area. In an era of explosive data growth, using only Korea's data is an act that impedes upon the development of technology. Therefore, it is necessary to secure domestic and international data interoperability by establishing a foundation for using foreign data in Korea through the utilization of an object identification system that is equally applicable both domestically and internationally.

7.2.2 Control Tower for Interoperability of Data

The governance that allows negotiation between stakeholders is required in order to secure the interoperability of city data in a smart city. For this, it is necessary to establish a general governance system for the subject of data acquisition, ownership, and scope of use by distinguishing public and private sectors. Policies, systems, manpower, standardization, and environment should be considered to establish systems and policies to secure data interoperability through governance and to facilitate joint data use.

7.2.3 Integrated Management System from Creation to Disposal of Data

Data interoperability can be secured by data management system. The data management system refers to a series of processes from creation to disposal of data which is called data lifecycle management. The integrated data lifecycle management plan is required to establish a data management system. In order to build the integrated data lifecycle management plan, it is necessary to make a standard about data management through the establishment of intermediate stages between data generation and disposal and by defining the functions for each stage.

In particular, various data-related specifications, such as data interface specifications for data sharing, data models, and data identification, are required and then the management system apply the specifications to the data lifecycle management. In addition, consultations among various stakeholders and establishing policies and systems are required for comprehensive data management. Overall, discussion from data generation to disposal is necessary through data governance or a consultative body that can strike a compromise among various stakeholders.

7.3 Guidelines for Securing Interoperability of Smart City Data

7.3.1 Establishment of Data Management System for Integrated Data Management

The data life cycle can be composed of five stages by integrating stages with similar purposes based on the characteristics of smart city data. The data life cycle can be composed of life cycle planning, data collection, data processing and storage, data processing and analysis, and data utilization.

First, it is necessary to establish a plan for the data lifecycle. Based on smart city services, the characteristics of data should be identified, and based on these characteristics, plans for the stages of data collection, processing, analysis, and utilization should be established. In addition, when issues or difficulties arise during the data life cycle process, problems should be resolved by applying feedback starting from the planning stage.

Second, the data collection stage refers to collecting calculated information for data management. It is necessary to utilize a universal interface technology and data model commonly used to secure interconnection and interoperability between different platforms.

The third stage is the data processing and storage stage of the data life cycle. This stage refers to the process of refining collected information according to a common standard format. Furthermore, it includes the process of preserving or discarding data by storing data in the storage module with the smart city platform.

The data analysis stage is the next stage. This stage refers process of handling security issues in smart city services. Data privacy and security capabilities can be strengthened through data masking by distinguishing between identified and non-identified data. Moreover, this stage also includes the step of analysing data for the purpose of presenting smart city issues and policy proposals.

The final stage of lifecycle is data utilization. This stage refers to the process of using the analysed data for smart city services. For example, through the data analysis stage, the data relation between different service can be discovered and the relation can be used to make new smart city services. In addition, this stage includes the process of opening and sharing data related to smart city services through other platforms and public portals.

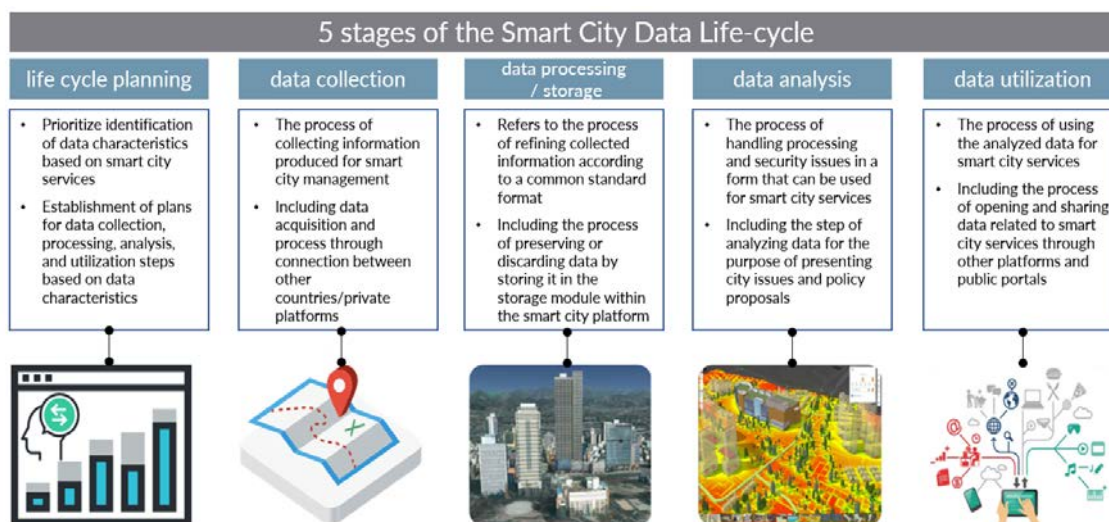


Figure 7.3.1-1: states of the smart city data Life cycle

7.3.2 Establishing a Data Identification System through Global Uniqueness of City Data and Objects

It is necessary to establish an identification system to secure data interoperability between different services or platforms. An ID, identifiable for each data, is provided through the establishment of an identification system. Through this, the desired data can be viewed, shared, and tracked regardless of service or platform. The following are required to use the functions of this identification system.

First, it should be possible to identify various data. It should support the function of identifying various tangible or intangible resources such as city assets, places, services, people, and documents in a consistent way using an identification system. Identifiers should be encoded relatively independently of the language and culture of each country in the world and be applicable to various identifier transmission mechanisms such as numbers, URIs, QRs, and RFIDs.

Second, the global uniqueness of the data should be guaranteed. Identifiers assigned to various resources of the city should be designed to have global uniqueness not only within the city, but also in the country and the world. As the identifier is the key to interoperability for data sharing, there should be a governance system that can assign, collect, and manage identifiers internationally in real-time.

Thirdly, to establish a universal data exchange system, standard master data should be developed and shared among interested parties worldwide. Standard master data is the reference data that becomes the basis of numerous data, and the attribute information and exchange mechanism of international standard master data that describes the identifier using the identifier as a key should be developed and built together. In addition, master data may have various attributes according to industry requirements, and standards for such attribute data are essential.



Figure 7.3.2-1: Characteristic of Data Identification system

7.3.3 Developing Governance for City Data System and Policy Establishment

It is necessary to have a function that can properly manage data with life cycles such as production, collection, storage, processing, utilization, and disposal of city data. Smart city data governance plays various roles such as data strategy, policies, standards, processes, organizational roles, and responsibilities; and the main functions of governance are data quality management, metadata management, lifecycle management, data security, and privacy protection, which are all crucial.

It plays a key role in forming a data ecosystem by establishing a city data-sharing system and strategically utilizing various data. Smart city data governance is important as it can discover new opportunities by converging and integrating data on a single service to share it throughout the city and improve the data utilization capabilities of local government members by sharing knowledge on data utilization. The data ecosystem constitutes a collaboration system that can accumulate and share data connection experiences, and many stakeholders should participate to create new values. For this, it is necessary to prepare the legal, institutional, and administrative foundations necessary for building a data ecosystem and play a role in coordinating the interests of various organizations.

7.4 Utilization of NGS-LD for data interoperability

Data interoperability is a key element that can create new services by utilizing the various services provided in smart cities. As described above, in order to secure data interoperability, it is necessary to establish data governance, data management system, and data identification system. Before establishing a data interoperability system, a policy or legal foundation for data interoperability should be established through consultation with policy-related parties through data governance.

In addition, it is important to match the data format to share data between different platforms or domains, as well as to manage the lifecycle of the data by applying an integrated management system. In particular, using a common interface system in data lifecycle is essential to provide data interoperability between different platforms. Therefore, NGS-LD can play a key role in ensuring data interoperability. Information model of NGS-LD can express relationships between data.

The Information Model can use the Property graph model to express Entity, property, and relationship of data, which are the basic concepts of JSON-LD used in NGS-LD. In addition, NGS-LD defines standardized RESTful APIs for create, retrieve, update, and delete context data, these APIs facilitate the interaction between system and applications in a consistent manner. Lastly, NGS-LD employs ontologies and semantic annotations to ensure a shared understanding of data. This helps in aligning data from different sources and systems. Therefore, in order to secure data interoperability in smart cities, NGS-LD can connect data between different platforms and domains, so it is essential for establishing a management system, identification system, and governance of smart city data.

Annex A: Change history

Date	Version	Information about changes
May, 19 th 2023	0.0.1	First draft of the present document
September, 14 th 2023	0.1.1	Stable draft approved
September, 27 th 2023	0.9.0	Final draft for approval
October, 2 nd 2023	0.9.1	Final Draft review by Technical Officer before TB approval
October, 2 nd 2023	0.9.2	Figures update and minor text revisions
October, 30 th 2023	1.1.1	Technical Officer Review for publication pre-processing
November 2023	1.1.1	First published version

History

Document history		
V1.1.1	December 2023	Publication