ETSI GR CIM 023 V1.1.1 (2024-01)

Context Information Management (CIM); NGSI-LD; Case Study of NGSI-LD Adoptions

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Reference
DGR/CIM-0023

Keywords
application, smart city, smart water, use case

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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

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

The NGSI-LD specification [i.1] has been implemented and deployed globally. The present document provides several adoption cases as a proof of disseminations and serves as the reference material for the future users of NGSI-LD. Each adoption case illustrates what is a deployed system and services, how the NGSI-LD standard is used. Not all the adoptions are not listed here but there are more open sources that implement NGSI-LD and more deployments out there. Therefore, the present document would be revised later to have more cases.

Introduction

The NGSI-LD specifications provide data management for different systems (e.g. smart city) leveraging Linked Data. While the NGSI-LD Primer provides the developer guide, the present document provides where and how NGSI-LD are used in real deployments.

Having adoption cases in the present document is helpful for delegates of ETSI ISG CIM group as well as users of NGSI-LD. With the description for each adoption, it is better understandable how to apply the standard for data management platform in different services. The feedback from the deployments such as extensions, potential API and each conclusion are for the delegates to consider future contributions to the specifications.

So far, the adoption cases cover Korean, Indian and European deployments including smart city, data marketplace and water management domains. This would be extended to cover other regional adoptions soon with different open source or commercial implementations.

1 Scope

The present document provides the case studies of NGSI-LD adoptions. Basically, each case study consists of each deployed system introduction with its architecture and adopted specifications. Then it is followed by implementation extensions other than the NGSI-LD specifications, also interworking and modelling aspects. Based on the analysis, the case study provides new functional requirements and recommendations for the future NGSI-LD standardizations if there is any.

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.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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 013 (V1.1.1): "Context Information Management (CIM); NGSI-LD Test Purposes Descriptions".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

AI	Artificial Intelligence
AMQP	Advanced Message Queuing Protocol
API	Application Programming Interface
CCTV	Closed-Circuit TeleVision
CPS	Cyber-Physical System
CRUD	Create Read Update and Delete
DNA	Data, Network and AI

EISS	Epidemiological Investigation Support System
ETL	Extract, Transform, Load
ID	IDentifier
IoT	Internet of Things
IUDX	India Urban Data eXchange
KDCA	Korea Disease Control & Prevention Agency
KETI	Korea Electronics Technology Institute
LPWA	Low Power Wide Area
ML	Machine Learning
MQTT	Message Queuing Telemetry Transport
NGSI-LD	Next Generation Service Interface-Linked Data
ODALA	Collaborative, Secure, and Replicable Open Source Data Lakes for Smart Cities
OIDC	OpenID Connect
R&D	Research and Develoment
RDF	Resource Description Framework
REST	REpresentational State Transfer
SAREF	Smart Applications REFerence ontology
SEAS	Smart Energy Aware System
TLS	Transport Layer Security
UI	User Interace
URI	Uniform Resource Identifier
URN	Uniform Resource Name

4 Adoption Case Study 1: Smart City Data Hub (South Korea)

4.1 Introduction

In 2018, the National Smart City Strategic Program was launched and more than 100 organizations and 2 pilot cities joined the program. It consists of 3 projects having 1 R&D project and 2 pilot projects in Siheung and Daegu city. The role of the 1st project in the program is the technology provider and the scope of the core technology includes smart city data hub, massive IoT and digital twin. The Smart City Data Hub has been deployed by the 2nd and 3rd projects in the two cities with smart city service implementations (e.g. disaster management).

The main motivation of the smart city program is to build data-driven smart cities upon the digital transformed cities. To enable data-driven smart cities, a data centric smart city platform is the key and in case of South Korea, it is Smart City Data Hub. The main role of the city data platform is to gather city data from heterogeneous data sources (e.g. public data portal, legacy systems) and then process, analyse and distribute data to city services and external systems.

There are many different data, in terms of syntax, semantics and periodicity, that gets collected to the city data platform. Converting those data into common data models is necessary process for better data usage and less cost by service applications. Also, for further usability of various domain data, linked data concept is considered. From ETSI GS CIM 009 [i.1], NGSI-LD standard interfaces which fulfilled basic requirements to manage city linked data. To leverage the linked data in the Smart City Data Hub, semantic web technologies with a smart city core ontology have been used to see the potential of linked data.

Figure 4.1-1: Overview of National Smart City Strategic Program in South Korea

4.2 System Architecture

Korea Electronics Technology Institute (KETI) consortium in the 1st project designed the reference architecture of Smart City Data Hub as illustrated in Figure 4.2-1, which has been used the other two projects for their pilot deployments. The architecture has been implemented by the consortium and has been released as open source, named City Data Hub.

As intended by the NGSI-LD technology, the data hub collects city data from existing data systems. There are different types of data sources, for instance IoT platforms (e.g. oneM2M), open data from public portals, legacy databases. that are providing data to the data hub. The data hub manages collected data and utilizes the data in different purposes (e.g. analytics) so it can be used in different city services. Also as a data platform, it provides security and other management capabilities.

From the reference architecture, there are eight functional modules including the API gateway. City data gets collected by the data ingest module and be stored in and managed by the data core module. The analytics, marketplace and semantic modules consume data from the data core via NGSI-LD APIs and provides their functionalities to users. Other non-data-handling modules provide platform managements.

The API gateway protects the platform from external applications/clients with token authentication with the security module, API routing/blocking and request rate limit. The security module provides user account and client management so it supports authentication and authorization with OAuth 2.0. The cloud management module enables system administrator to monitor and manage the cloud infrastructure to run the Smart City Data Hub. Hybrid cloud, which uses private and public clouds together, infra can be set up and managed such as monitoring and metering.

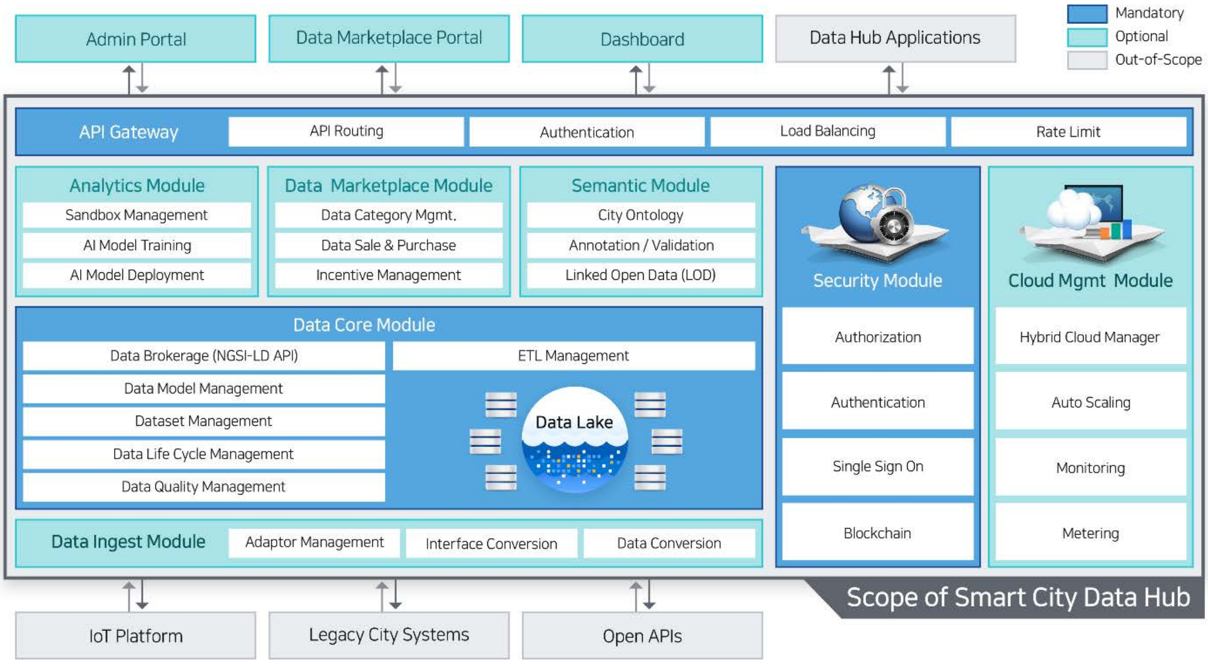
Mandatory
Optional
Out-of-Scope
Admin Portal
Data Marketplace Portal
Dashboard
Data Hub Applications
API Gateway
API Routing
Authentication
Load Balancing
Rate Limit
Analytics Module
Sandbox Management
AI Model Training
AI Model Deployment
Data Marketplace Module
Data Category Mgmt.
Data Sale & Purchase
Incentive Management
Semantic Module
City Ontology
Annotation / Validation
Linked Open Data (LOD)
Security Module
Authorization
Authentication
Single Sign On
Blockchain
Cloud Mgmt Module
Hybrid Cloud Manager
Auto Scaling
Monitoring
Metering
Data Core Module
Data Brokerage (NGSI-LD API)
ETL Management
Data Model Management
Dataset Management
Data Life Cycle Management
Data Quality Management
Data Lake
Data Ingest Module
Adaptor Management
Interface Conversion
Data Conversion
Scope of Smart City Data Hub
IoT Platform
Legacy City Systems
Open APIs

Figure 4.2-1: Reference Architecture and Data Flow of Smart City Data Hub

The data stored by the data broker, that implements NGSI-LD APIs, interworks with other modules in the data hub. Therefore, NGSI-LD APIs been used also to provide interoperability internally to the system. It is an important aspect of extensibility since other data utilization modules can be added, and they implement NGSI-LD APIs for interoperability. Also, the data core module serves city data to the external services/systems so having standard interfaces is beneficial.

The analytics module provides AI/ML based analytics and prediction while providing data pre-processing, model training/testing and model batch deployment capabilities. Data for model training and batch inference is provided by the data core module. During the training dataset preparation, multiple datasets, possibly from different domains, get mashed-up (e.g. parking events and weather). Several data pre-processing and training algorithms are supported so user can build AI/ML models for different service needs. Each trained models can be deployed with batch schedules. On each schedule, a model gets inference input data from the data core and ETL procedure and perform inference. Inference result (e.g. parking congestion prediction) from ML models can be also stored into the data core, so it can be used by other city applications as well.

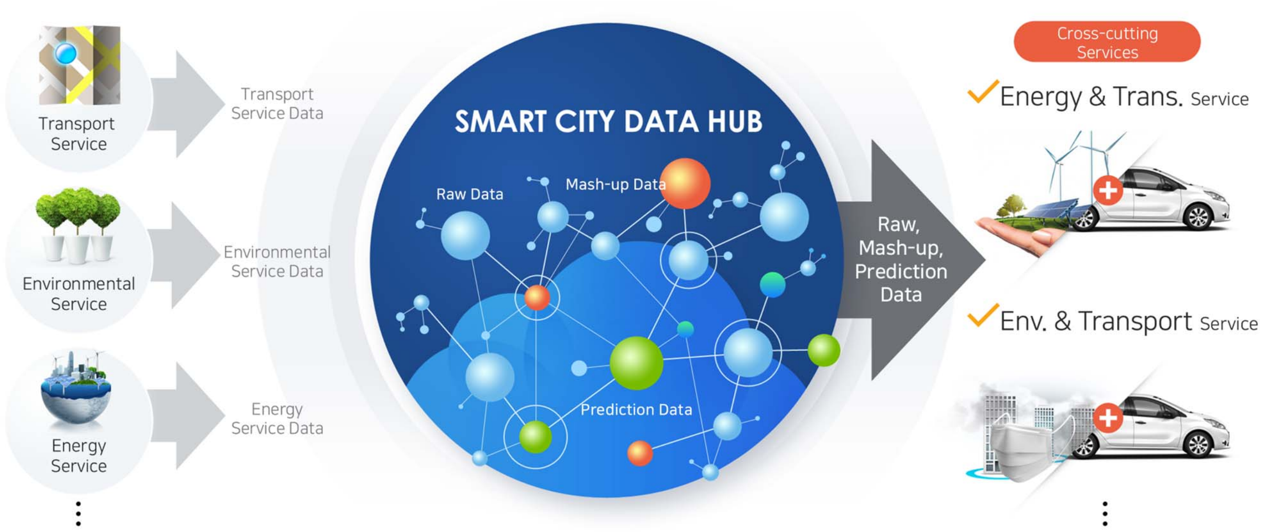
Transport Service
Transport Service Data
Environmental Service
Environmental Service Data
Energy Service
Energy Service Data
SMART CITY DATA HUB
Raw Data
Mash-up Data
Prediction Data
Raw, Mash-up, Prediction Data
Cross-cutting Services
Energy & Trans. Service
Env. & Transport Service

Figure 4.2-2: City Data Utilization on Smart City Data Hub

The data marketplace module is the back-end of the data marketplace portal. The data portal is also implemented to boost data distribution between data providers and consumers. It has been said that distributing data to 3rd parties to realize data-driven smart city is more important than just gathering big data from city infrastructures. A data provider can sell data products which is stored in the data core. The marketplace module sends NGSI-LD queries to find user's dataset, so selected data can be prepared as data products. When preparing the product, by the provider's preference, specific attributes can be selected and even attribute names can be changed from the original NGSI-LD entity instances. Purchased data can be used by fetching and receiving asynchronous notification which leverages NGSI-LD entity retrieval and subscription/notification features.

The semantic module includes a triple store which get RDF triple data from a semantic annotator. The annotator gets data over NGSI-LD APIs from the data core module and creates annotations with smart city ontologies. There has been defined the smart city core ontology for domain extensions (e.g. parking ontology).

Following the reference architecture designed in the program, in Daegu, commercial data hub implementation, other than open source based, has been deployed. Figure 4.2-3 describes the reference architecture of the Daegu case. As the extension to the reference model to meet the requirements for Daegu such as legacy system interfaces and video stream management in the data ingest module. For the data hub in the pilot city, several AI-based services have been tested. City bus routes have been optimized for citizens and safety services like police patrol routes planning and CCTV deployment optimization also been successfully deployed. With the data driven safety services as one of the best practices for smart city data hub, the services have been disseminated in other cities with data hub deployments.

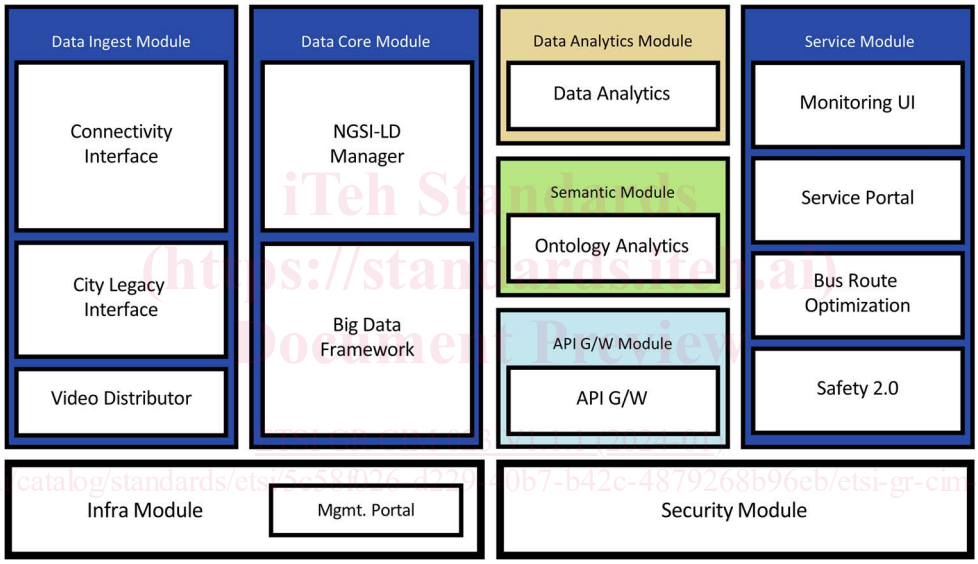

Figure 4.2-3: Reference Architecture of Daegu Smart City Data Hub

4.3 NGSI-LD Adoptions

City Data Hub, open source implementation of the Smart City Data Hub, adopts the essential NGSI-LD APIs as summarized in Table 4.3-1. The NGSI-LD API specification defines temporal data manipulation such as POST to "/temporal/entities/{entityId}" resource. In case of City Data Hub, as the specification also allows as a deployment scenario, data manipulation gets handled over "/entities/" and its sub-resources. Only the historical data query is used via "/temporal/entities" and "/temporal/entities/{entityId}" resources.