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Context Information Management (CIM); Handling of Linked Data Event Streams with NGSI-LD

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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 present document investigates how LDES sources can be consumed by NGSI-LD context brokers and vice versa how NGSI-LD context brokers can make their context information available to LDES consumers.

1 Scope

The present document brings an introduction of the Linked Data Event Streams (LDES) and TREE specifications and maps part of its key concepts to the NGSI-LD model. Also, a mapping of the NGSI-LD entity representation to LDES members is proposed.

The second part of the present document focuses on the architectural considerations of consuming and publishing LDES with NGSI-LD context brokers.

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] ["Linked Data Event Streams Specification"](#).
- [i.2] W3C®: ["The TREE hypermedia specification"](#).
- [i.3] ETSI GS CIM 009 (V1.8.1): ["Context Information Management \(CIM\); NGSI-LD API"](#).
- [i.4] OGC®: ["Web Feature Service"](#).
- [i.5] [OGC® APIs](#).
- [i.6] W3C® Recommendation 21 March 2013: ["SPARQL 1.1 Query Language"](#).
- [i.7] [Linked Data Event Streams Server \(Flemish Smart Data Space\)](#).
- [i.8] [Linked Data Event Streams JSON-LD context](#).
- [i.9] [Slippy map tilenames](#).
- [i.10] [Pagination \(Flemish Smart Data Space\)](#).
- [i.11] [Reference Fragmentation \(Flemish Smart Data Space\)](#).
- [i.12] [Geospatial fragmentation \(Flemish Smart Data Space\)](#).

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

LDES member: object whose status cannot change after it was created

LDES view: event stream view that connects the collection to the root node such that all members of the collection can be found

Linked Data Event Stream (LDES): collection of immutable objects (such as version objects & sensor observations)

NGSI-LD attribute: reference to both an NGSI-LD Property and to an NGSI-LD Relationship

NGSI-LD attribute Type: categorization of an NGSI-LD Property or NGSI-LD Relationships

NGSI-LD element: any JSON element that is defined by the NGSI-LD API

NGSI-LD entity: informational representative of something that is supposed to exist in the real world, physically or conceptually

NGSI-LD entity type: categorization of an NGSI-LD entity as belonging to a class of similar entities, or sharing a set of characteristic properties

TREE collection: collection containing members following an imposed shape

NOTE: The members may be spread across multiple nodes.

TREE member: object that is part of a collection

TREE node: HTTP page, which itself may already contain members, that can contain relationships to other nodes

TREE ontology: hypermedia specification for fragmenting collections

TREE root node: home page, which itself may already contain members, through whose linked pages all members can be found

TREE shape: technical description of the structure to which objects from the collection has to conform

3.2 Symbols

Void.

3.3 Abbreviations

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

API	Application Programming Interface
DCAT	Data CATalog vocabulary
FSDS	Flemish Smart Data Space
HTTP	HperText Transfer Protocol
JSON	Java Script Object Notation
LDES	Linked Data Event Streams
NGSI	Next Generation Service Interface
OGC	Open Geospatial Consortium
SEMIC	Semantic Interoperability Community
SPARQL	SPARQL Protocol and RDF Query Language
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
WFS	Web Feature Service

NOTE: TREE is not an abbreviation, but the name of an ontology for fragmenting collections of items across multiple HTTP pages in a 'tree'-like way (linear, hierarchical, tiling-based, etc.).

4 Linked Data Event Streams

4.1 Introduction

The Linked Data Event Streams (LDES) specification enables datasets to be repurposed in different contexts. All kinds of datasets are in scope: static data, such as bibliographic records, as well as real-time data, such as sensor observations. A dataset is represented as an event source, which is an append-only collection of immutable objects: each time the dataset changes, a new object, called member, is added to the collection and is expected never to change. Typically, a member is a version object, but this can also be an immutable sensor observation or an activity object describing the occurred action.

The LDES specification [i.1] is available at <https://w3id.org/ldes/specification>.

NOTE 1: A collection imposes a certain shape on its members expressing the structure of the members. For example, members require to have a type "Vehicle" and a property "speed".

EXAMPLE 1: "Bob's vehicle speed is 10 km/h" can be modelled as an immutable sensor observation.

EXAMPLE 2: "Bob's vehicle brand is Mercedes" can be modelled as a version object of Bob's vehicle.

EXAMPLE 3: "Bob's vehicle's speed was measured at 10, 20, and 30 km/h" can be represented with three LDES members.

The LDES specification is based on the TREE hypermedia specification to publish collections. When a collection becomes too big for one HTTP page, fragmentation in multiple pages is needed. The TREE specification originates from the idea to provide an alternative to one-dimensional HTTP pagination. It allows to fragment a collection of items and interlink these fragments. Instead of linking to the next or previous page, a relation between two fragments, called TREE nodes, describes what elements can be found by following the link to another fragment.

The TREE specification [i.2] is available at <https://w3id.org/tree/specification>.

EXAMPLE 4: A TREE node identified with query parameter "time=2024-05-14" contains members with a modifiedAt property greater than "2024-05-14".

EXAMPLE 5: A TREE relation describes that TREE node <?time=2024-05-14> has members with a modified greater than "2024-05-14". The relation has as specific type "tree:GreaterThanRelation", has tree:node property with value <?time=2024-05-14>, and has a tree:path property with value modifiedAt.

NOTE 2: LDES typically uses one-dimensional pagination where updates are appended to a "latest" fragment. This way, consumers only need to be subscribed to one fragment for updates. When this latest fragment reaches a certain threshold, a new, latest fragment is created.

NOTE 3: The members of an LDES can be published through different types of fragmentations, which are called TREE views. For example, a view can first fragment a collection in geographical regions, and then enable a one-dimensional pagination per region.

With LDES, data consumers can set up pipelines to automatically replicate the history of a dataset and stay in sync with the latest updates. Today, custom code has to be created to integrate data, which makes it rather expensive to integrate multiple data sources. With LDES, a technical standard [i.1] was created that allows data to be exchanged across silos using domain-specific ontologies. An LDES allows third parties to build specific services (ETSI GS CIM 009 [i.3], Web Feature Service (WFS) [i.4], OGC APIs [i.5], SPARQL [i.6]) that are always in sync with the original dataset.

The next clauses describe how the TREE and LDES models map with the NGSI-LD meta model.

4.2 TREE to NGSI-LD mapping

The TREE vocabulary defines 5 classes, and 16 properties in total. The present document only maps the classes and properties that are required to be retrievable by LDES clients. Features like imports, view descriptions, shapes, remaining items, etc. are optional in the TREE specification [i.2] and therefore out-of-scope. Figure 4.2-1 demonstrates for a subset of TREE classes and properties how they map to NGSI-LD Entities, Relationships, Properties and value.

NOTE 1: Following prefixes are used to enhance readability:

- tree: <https://w3id.org/tree#>
- dcat: <http://www.w3.org/ns/dcat#>

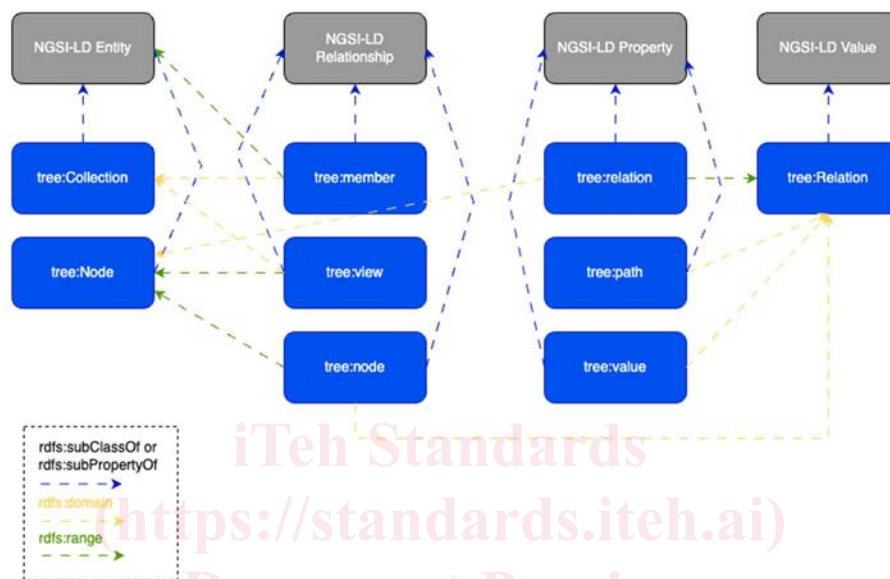


Figure 4.2-1: High-level mapping of TREE Specification to NGSI-LD Meta Model

The class tree:Collection can be mapped to NGSI-LD entity. A collection corresponds with a dcat:Dataset and has two relationships:

- The tree:member relationship linking to other members (NGSI-LD entities) that are part of the TREE collection. Clause A.1 provides an example.
- The tree:view relationship towards a tree:Node being an endpoint (HTTP page) to retrieve members. Clause A.2 provides an example.

NOTE 2: The tree:member relationship typically only lists the members that are described in the same page.

The class tree:Node, being an HTTP page containing a part of the collection, can also be mapped to an NGSI-LD entity and has following property:

- the tree:relation property linking to another tree:Node. Clause A.2 provides an example.

The value of the tree:relation is an instance of a tree:Relation and is mapped as an NGSI-LD Value. More specifically, as a JSON-LD structured value. The reason is that a tree:Relation always is part of a tree:Node and therefore has no identity. The tree:Relation has following properties:

- A tree:node property (mandatory) containing the URL of another TREE node.
- A tree:path property (optional) indicating to which of the members' properties this relation applies.
- A tree:value property (optional) indicating a value constraint on the members' values.

NOTE 3: The tree:path and tree:value properties have to be used in conjunction to be useful for an LDES consumer.

NOTE 4: The tree:path and tree:value properties allow LDES consumers to decide whether to continue to the next node.

This clause demonstrates how TREE allows to:

- i) define a collection of NGSI-LD Entities;
- ii) define nodes that contain a subset of the collection; and
- iii) use qualified relations to guide consumers to retrieve relevant nodes.

In clause 4.3, it is presented how LDES is a specialization of a TREE collection to replicate versions of entities.

4.3 LDES to NGSI-LD mapping

The LDES vocabulary defines 7 classes, and 8 properties in total. Features like event source, retention policies, version or materialization are not required to be retrievable by LDES clients and therefore out-of-scope.

Figure 4.3-1 shows that the ldes:EventStream class is mapped to an NGSI-LD entity, similar to its super class tree:Collection. Two properties are introduced to enable versioning on the entities of a collection:

- The ldes:timestampPath is mapped to an NGSI-LD Property indicating how a member precedes another member in the LDES using a timestamp.
- The ldes:versionOfPath is mapped to an NGSI-LD Property indicating the non-version object of a member.

An example of these properties and how this resolves in an LDES member can be found in clauses 5.1 and A.3.

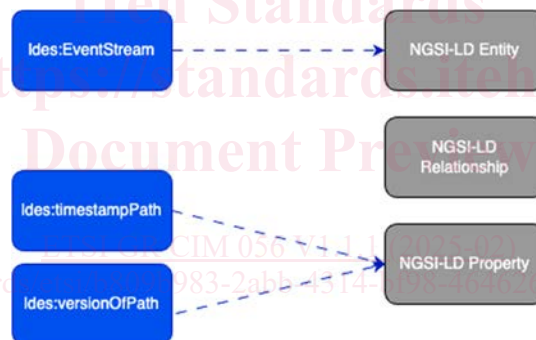


Figure 4.3-1: High-level mapping of Linked Data Event Streams data model to NGSI-LD Meta Model

This clause describes how LDES introduces versioning of entities using the timestamp and version of properties. This way, instances of the same entity have an explicit identifier and consumers know whether an entity version precedes another. In contrast with clause 4.6.6 in ETSI GS CIM 009 [i.3], entity instances of the same entity are not expected to come in chronological order. In clause 5, a way will be proposed to map an instance of an NGSI-LD entity to an LDES member.

5 Mapping NGSI-LD to LDES

5.0 Foreword

This clause 5 describes what needs to be adapted to the NGSI-LD Meta Model to map with the LDES standard. First, it will be discussed how the NGSI-LD entity representation from the core interfaces maps to one member. Then, it will be presented how the temporal representation of an entity can be mapped to multiple members.

5.1 NGSI-LD Data Representation to LDES mapping

5.1.1 NGSI-LD entity representation to LDES member

Here is a presentation of an instance of an entity with identifier urn:person:1. The system attributes createdAt and modifiedAt are provided to explain how a version can be created based on these properties.

EXAMPLE 1: NGSI-LD entity as base example to demonstrate LDES members:

```
{
  "id": "urn:person:1",
  "type": "Person",
  "name": {
    "type": "Property",
    "value": "Bill Smith",
    "createdAt": "2022-08-09T18:25:02Z",
    "modifiedAt": "2022-08-10T18:25:02Z"
  },
  "createdAt": "2022-08-09T18:25:02Z",
  "modifiedAt": "2022-08-10T18:25:02Z"
}
```

A member of an LDES represents an entity at a certain time. With the modifiedAt temporal property of an NGSI-LD entity, the last time the entity has been modified can be used to describe the latest version of an entity. Example 2 shows how the modifiedAt value is appended to create a version-specific identifier. For the timestamp property of a member, it is not allowed to use modifiedAt, because this is a system attribute and is preserved for internal usage in a context broker. Therefore, the present document proposes to define the observedAt temporal property at the entity level with following definition:

- observedAt is defined as the temporal Property at which a certain Entity became valid or was observed. For example, a person Entity with certain Properties and Relationships was observed at this point in time.

Example 2 shows how the observedAt property was added to the entity version. This version represents how the entity was observed at the time of modification.

It is also proposed to add the observedAt property on all the Relationships and Properties where this is not yet defined. Example 1 shows how the observedAt property was added to the name Property.

An isVersionOf property is added as non-reified property (the value only contains the entity id) containing the non-version entity id. Typically, LDESs use isVersionOf from the Dublin Core initiative (<http://purl.org/dc/terms/isVersionOf>).

All system attributes are hidden as this should not be part of the LDES publication.

EXAMPLE 2: Versioned entity using the observedAt temporal property:

```
{
  "id": "urn:ngsi-ld:Person:1:2022-08-10T18:25:02Z",
  "type": "Person",
  "isVersionOf": "urn:ngsi-ld:Person:1",
  "observedAt": "2022-08-10T18:25:02Z",
  "name": {
    "type": "Property",
    "value": "Bill Smith",
    "observedAt": "2022-08-10T18:25:02Z"
  }
}
```

EXAMPLE 3: A simplified representation of the versioned entity is also possible:

```
{
  "id": "urn:ngsi-ld:Person:1:2022-08-10T18:25:02Z",
  "type": "Person",
  "isVersionOf": "urn:ngsi-ld:Person:1",
  "observedAt": "2022-08-10T18:25:02Z",
  "name": "Bill Smith"
}
```