Core Concept of OGC MF-JSON Encoding and OGC API – Moving Features

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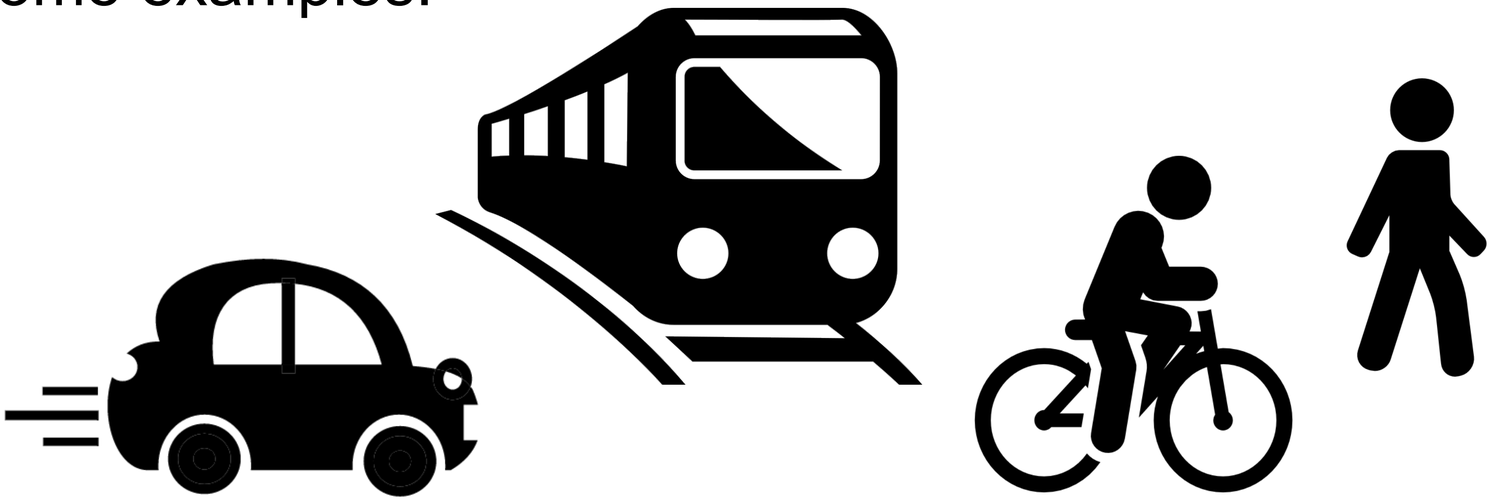
Agenda

- Overview of OGC Moving Features JSON encoding (MF-JSON)
- Overview of OGC API – Moving Features (API-MF)
- Implementations for MF-JSON and API-MF

Overview of OGC MF-JSON

Various types of moving features in the real world

- **Moving Feature: feature whose location changes over time**
- We can easily imagine some examples:
  - Cars,
  - Trains,
  - Bicycles,
  - Pedestrians,
  - …

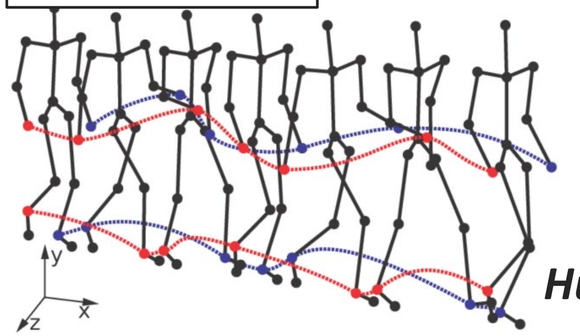


- Their positions changed over time, and they are usually represented by Points
  - How about its **shape**? With other representations, such as Curve, Surface, ...
  - How about its **properties**? Such as speeds, directions, capacities, …

Various representations with moving features

- **Moving Feature: feature whose location changes over time**

Curve type



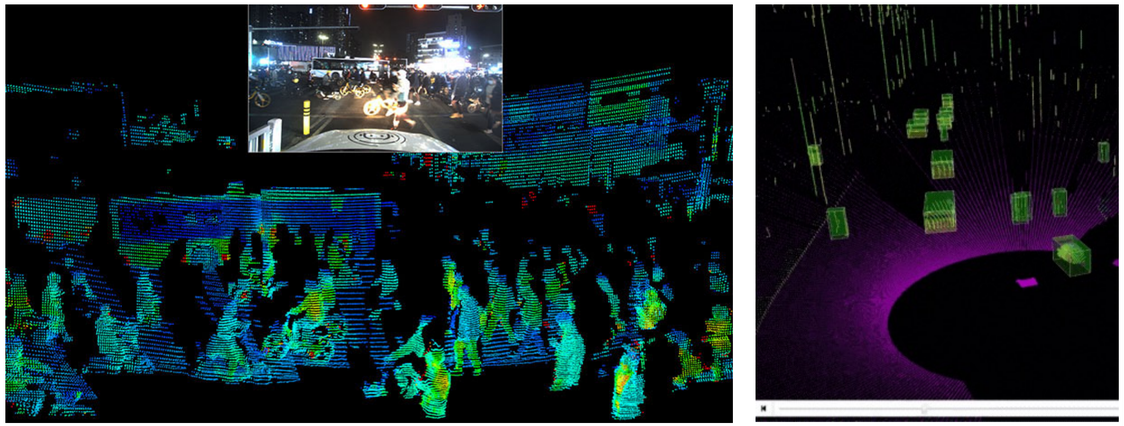
Human Motions

Trains

Surface type

Typhoon

Point Clouds type



Pedestrians

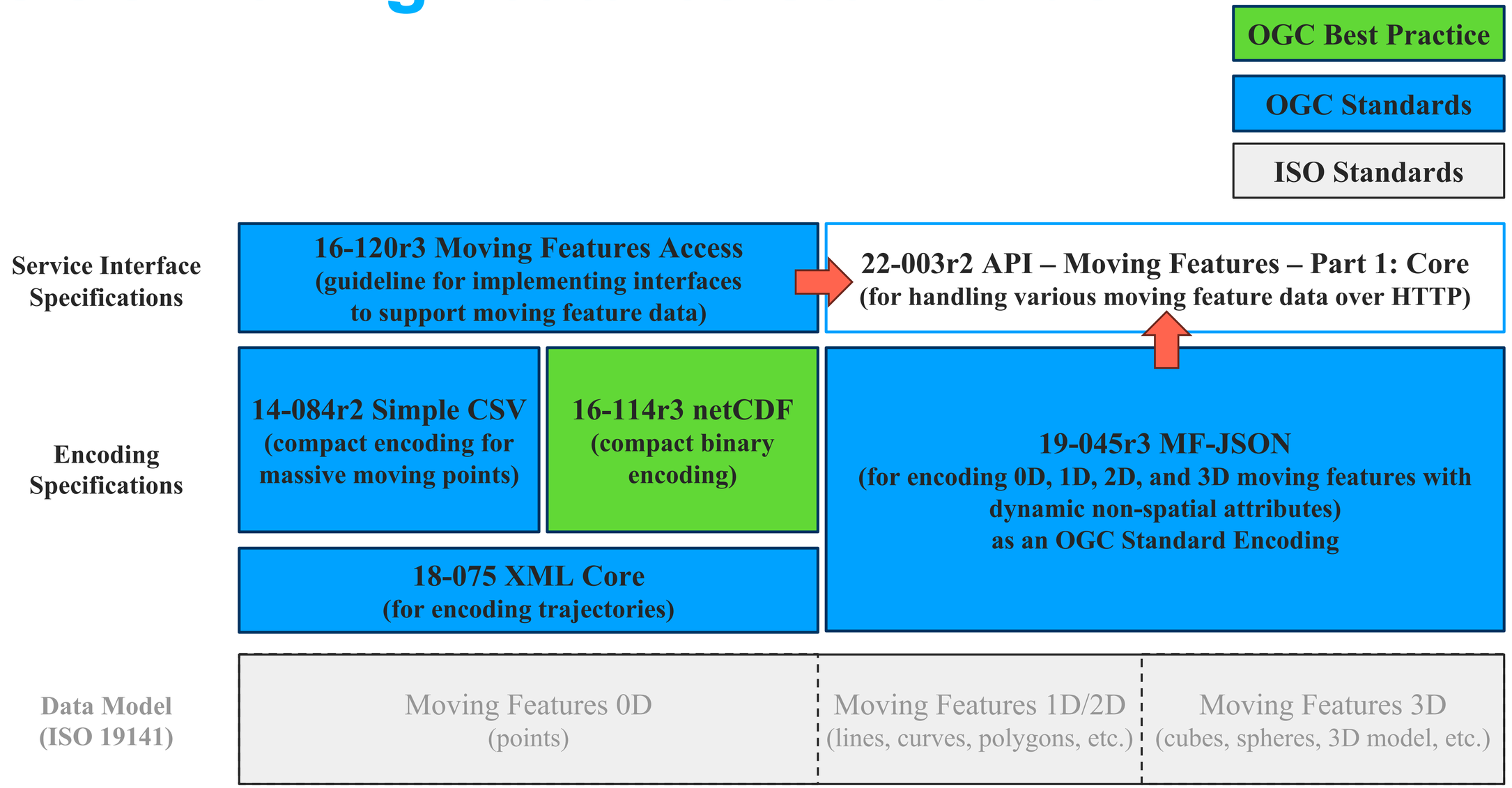
Image source:

1. https://matcha-jp.com/en/4409
2. https://github.com/aistairc/mf-cesium/wiki/Stinuum-Web-Manual
3. https://www.robosense.ai/en/tech-show-55
4. https://www.sama.com/3d-lidar-radar-point-cloud-annotation/
5. Balazia, Michal, and Petr Sojka. "Learning robust features for gait recognition by maximum margin criterion." *2016 23rd International Conference on Pattern Recognition (ICPR)*. IEEE, 2016.

The property also can be changed over time

Video source: https://avs.auto/#/

OGC Moving Features Standards



Two encoding formats of MF-JSON

(a) MF-JSON Trajectory

```
{
   "type": "Feature" ,
   "geometry": {
        "type": "LineString",
        "coordinates": [[...],[...],...]
    },
   "properties": {
        "datetimes": [...],
        ....
    },
   "bbox": ...
}
```

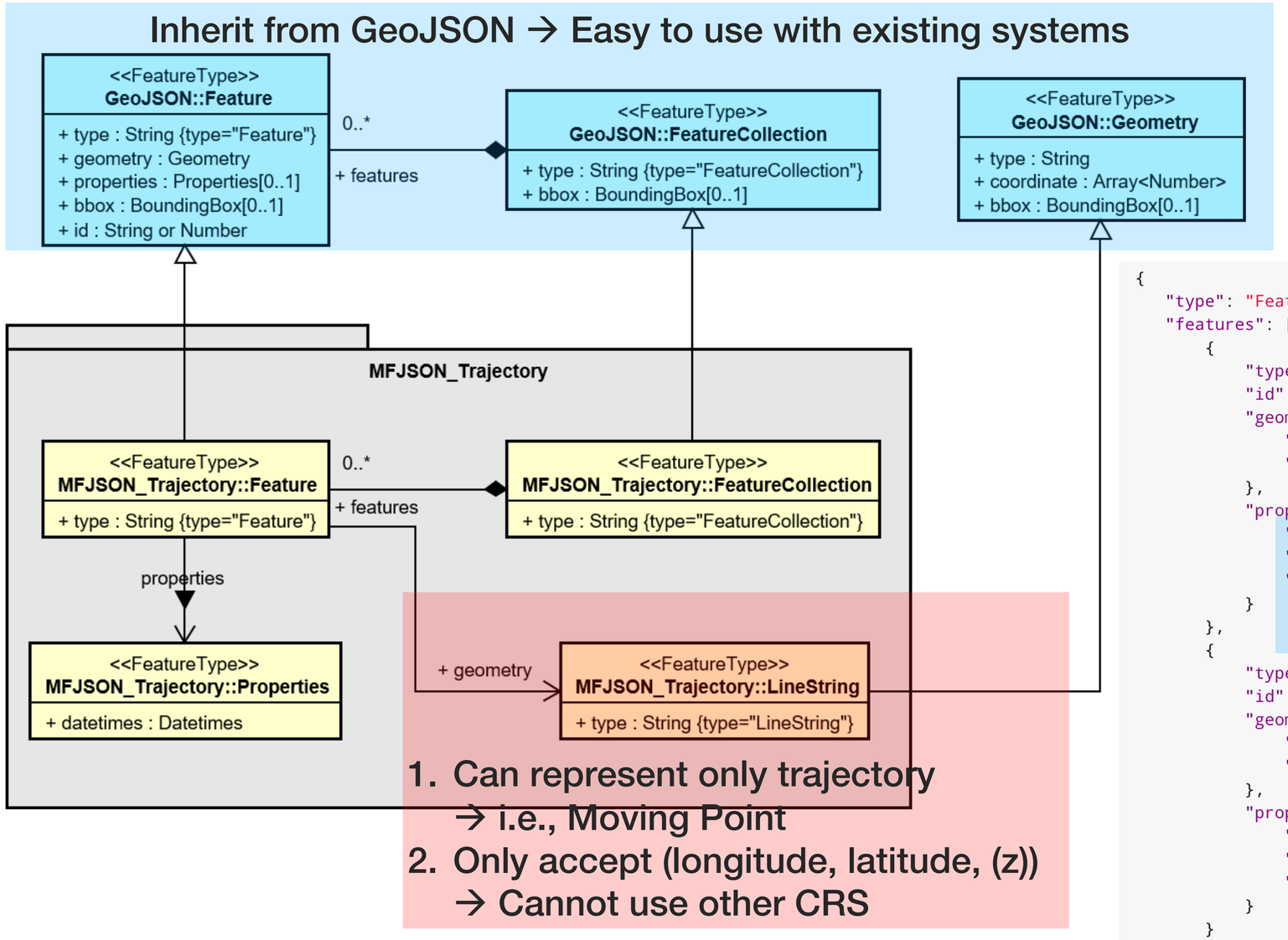
(b) MF-JSON Prism

```
{
   "type": "Feature" ,
   "geometry": ...,
   "properties": ...,
   "bbox": ...,
   "crs": {...},
   "trs": {...},
   "temporalGeometry": {
        "type": ...,
        "coordinates": [...],
        "datetimes": [...],
        ...
    },
   "temporalProperties": [...],
   "time": [...]
}
```

New members

Image source: OGC Moving Features Encoding Extension – JSON, https://docs.ogc.org/is/19-045r3/19-045r3.html

MF-JSON Trajectory




```
{
   "type": "FeatureCollection",
   "features": [
       {
           "type": "Feature",
           "id": "A",
           "geometry": {
               "type": "LineString",
               "coordinates": [[11.0,2.0], [12.0,3.0], [10.0,3.0]]
           },
           "properties": {
               "datetimes": ["2012-01-17T12:33:51Z", "2012-01-17T12:33:56Z", "2012-01-17T12:34:00Z"],
               "state": ["walking","walking"],
               "typecode": [1, 2]
           }
       },
       {
           "type": "Feature",
           "id": "B",
           "geometry": {
               "type": "LineString",
               "coordinates": [[10.0,2.0], [11.0,3.0]]
           },
           "properties": {
               "datetimes": ["2012-01-17T12:33:51Z", "2012-01-17T12:34:00Z"],
               "state": ["walking"],
               "typecode": [2]
           }
       }
   ]
}
```


With “datetimes”,
Users can add a user-defined temporal property

Image source: OGC Moving Features Encoding Extension – JSON, https://docs.ogc.org/is/19-045r3/19-045r3.html

MF-JSON Prism

A MF-JSON Prism document may contain JSON objects that represent instances with the following types, as well as primitives types of JSON null, true, false, string, number, and array.

- TemporalGeometry object (see 7.2.1)
  - TemporalPrimitiveGeometry object (see 7.2.1.1)
  - TemporalComplexGeometry object (see 7.2.1.2)
- TemporalProperties object (see 7.2.2)
  - ParametricValues object (see 7.2.2.1)
- CoordinateReferenceSystem object (see 7.2.3)
- MovingFeature object (see 7.2.4)
- MovingFeatureCollection object (see 7.2.5)
- LifeSpan object (see 7.2.6)
- BoundingBox object (see 7.2.7)
- Geometry object (see 7.2.8)
- Properties object (see 7.2.9)
- MotionCurve object (see 7.2.10)

There are many objects for MF-JSON Prism

Image source: OGC Moving Features Encoding Extension – JSON, https://docs.ogc.org/is/19-045r3/19-045r3.html

Key Features: TemporalGeometry

TemporalPrimitiveGeometry object

```
{
  // vbar | as a means to select ONE type.
  "type": "MovingPoint | MovingLineString | MovingPolygon | MovingPointCloud", //(MANDATORY)
  "datetimes" : [...],    //(MANDATORY)
  "coordinates": [...],   //(MANDATORY)
  "interpolation": "...", //(DEFAULT)
  "base": {...},          //(OPTIONAL)
  "orientations": [...],  //(OPTIONAL)
  "crs": {...},           //(DEFAULT)
  "trs": {...}            //(DEFAULT)
}
```

Special elements for temporal geometry (and 3D model)

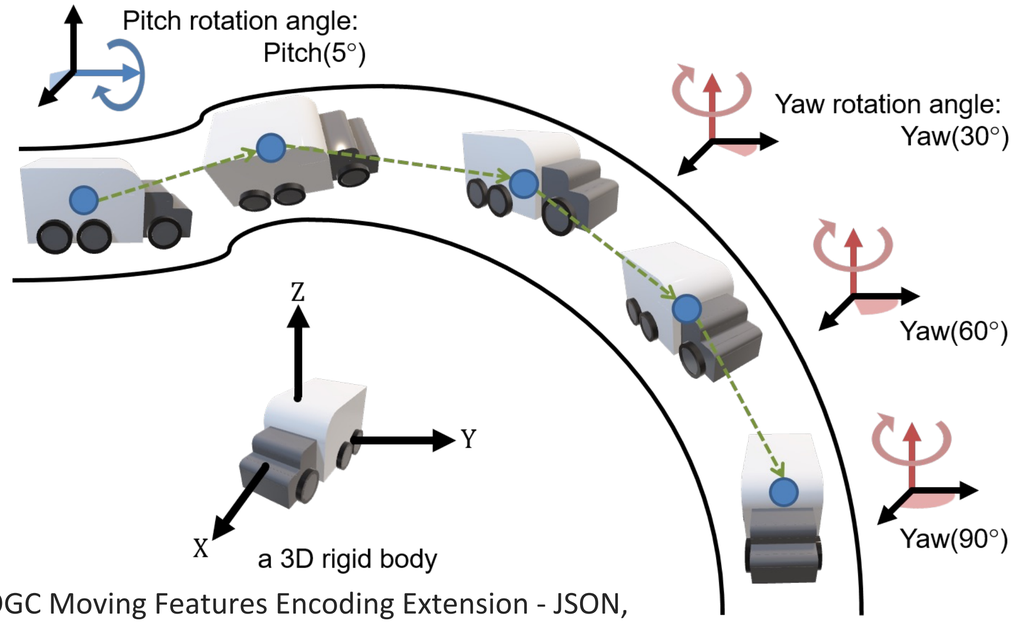


Image source: OGC Moving Features Encoding Extension - JSON, https://docs.ogc.org/is/19-045r3/19-045r3.html

TemporalComplexGeometry object

```
{
    "type": "MovingGeometryCollection",  // (MANDATORY)
    "prisms": [  //(MANDATORY)
        {
            "type": "MovingPoint | MovingLineString | MovingPolygon | MovingPointCloud",
means to select ONE type.
            "datetimes" : [...],    //(MANDATORY)
            "coordinates": [...],   //(MANDATORY)
            "interpolation": "...", //(DEFAULT)
            ...
        },
        ...
    ],
    "crs": {...}, //(DEFAULT)
    "trs": {...}  //(DEFAULT)
}
```

Array element: TemporalPrimitiveGeometry object

Key Features: Interpolation of Movement

Predefined MotionCurve object

```
{
    ....,
    "datetimes": [...],  //T={t_0, t_1, ..., t_n}
    "coordinates": [...], //G={G_0, G_1, ..., G_n}
    "interpolation": "Discrete|Step|Linear|Quadratic|Cubic", // vbar | as a means to select ONE.
    ....
 }
```

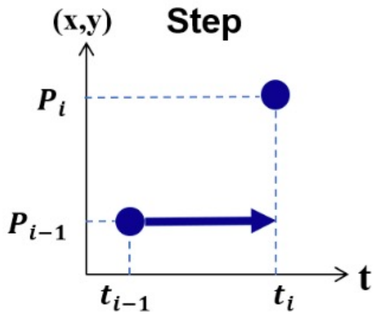
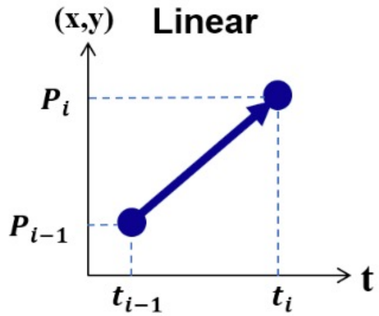
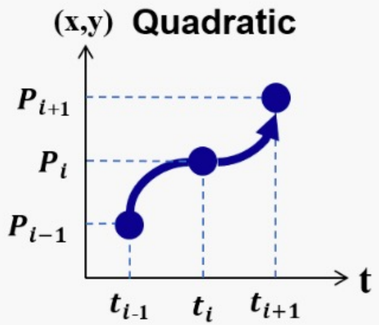
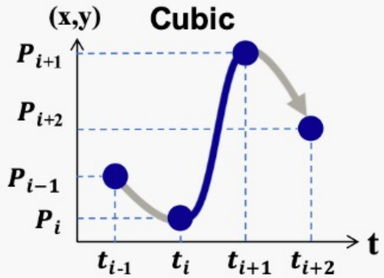
Names	Curves	Names	Curves
Step		Linear	
Quadratic		Cubic	

Image source: OGC Moving Features Encoding Extension – JSON, https://docs.ogc.org/is/19-045r3/19-045r3.html

Key Features: TemporalProperties

ParametricValues object

```
{
  "datetimes": [...], //(MANDATORY) a JSON Array of time instants
  "@property0": {     // @property0 whose name is any string defined by an application.
      "type": "Measure",          //(MANDATORY) a predefined string among `Measure`, `Text`, and `Image`
      "values": [...],            //(MANDATORY) a JSON Array of values
      "interpolation": "...",     //(DEFAULT) a predefined string or a URL
      "form": "...",              //(OPTIONAL) a unit of measurement
      "description": "any string" //(OPTIONAL) any string content for an application
  },
  "@property1": {     // @property1 whose name is any string defined by an application, but the name is not the same as
@property0.
      "type": "Text", // @property1 has values at the same time instants of @property0
      ...
  },
  "@property2" : {    // @property1 whose name is any string defined by an application, bu
@property0 nor @property1.
    "type": "Image",
}
```

Shared time information

Temporal property block

Predefined temporal property type

Type strings	Descriptions
Measure	The "values" member contains any numeric values.
Text	The "values" member contains any strings.
Image	The "values" member contains Base64 strings converted from images or URLs to address images.

Predefined interpolation for temporal property

Names	Descriptions
Discrete	The sampling of the attribute occurs such that it is not possible to regard the series as continuous; thus, there is no interpolated value if t is not an element in "datetimes".
Step	The values are not connected at the end of a subinterval with two successive instants. The value just jumps from one value to the other at the end of a subinterval.
Linear	The values are essentially connected and a linear interpolation estimates the value of the property at the indicated instant during a subinterval.
Regression	The value of the attribute at the indicated instant is extrapolated from a simple linear regression model with the whole values corresponding to the all elements in "datetimes".

Image source: OGC Moving Features Encoding Extension - JSON,
https://docs.ogc.org/is/19-045r3/19-045r3.html

Example of TemporalProperties object

```
"temporalProperties": [  //(OPTIONAL) dynamic non-spatial attributes, extended from 'properties'
  { // a group of temporal properties that are measured at the same times
    "datetimes": ["2011-07-14T22:01:01.450Z", "2011-07-14T23:01:01.450Z", "2011-07-15T00:01:01.450Z"],
    "length": {
        "type": "Measure",
        "form": "http://www.qudt.org/qudt/owl/1.0.0/quantity/Length", // a URI denoting a unit-of-measure
        "values": [1.0, 2.4, 1.0], // the array of values for "length", with the same number of elements as "datetimes"
        "interpolation": "Linear",
        "description": "description1" //(OPTIONAL)
    },
    "discharge" : {
        "type" : "Measure",
        "form" : "MQS", // a symbol for m^3/s(a cubic metre per second)
        "values" : [3.0, 4.0, 5.0],
        "interpolation": "Step"
    }
  },{
    "datetimes" : [1465621816590, 1465711526300],
    "camera" : {
        "type" : "Image",
        "values" : ["http://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/image1", "iVBORw0KGgoAAAANSUhEU......"],
        "interpolation": "Discrete"
    },
    "labels":{
        "type": "Text", // a predefined unit for a string value
        "values": ["car", "human"], // the array of values for "labels", with the same number of elements as "datetimes"
        "interpolation": "Discrete",
        "description": "description2" //(OPTIONAL)
    }
  }
],
```

Image source: OGC Moving Features Encoding Extension - JSON,
https://docs.ogc.org/is/19-045r3/19-045r3.html

Key Features: MovingFeature

{

Inherited from GeoJSON

- “type”: (Mandatory), “Feature”, the same semantics of GeoJSON
- “id”: (Optional), the same semantics of GeoJSON
- “geometry”: (Optional), the same semantics of GeoJSON
- “properties”: (Optional), the same semantics of GeoJSON
- “bbox”: (Optional), the same semantics of GeoJSON

- “time”: (Optional), the temporal coordinate range for MovingFeature
- “crs”: (Default: WGS84), the spatial coordinate reference system
- “trs”: (Default: ISO8601), the temporal coordinate reference system
- “temporalGeometry”: (Mandatory), the dynamic spatial attributes
- “temporalProperties”: (Optional), the dynamic non-spatial attributes

Additional properties for MF-JSON

}

Summary of OGC MF–JSON Encoding

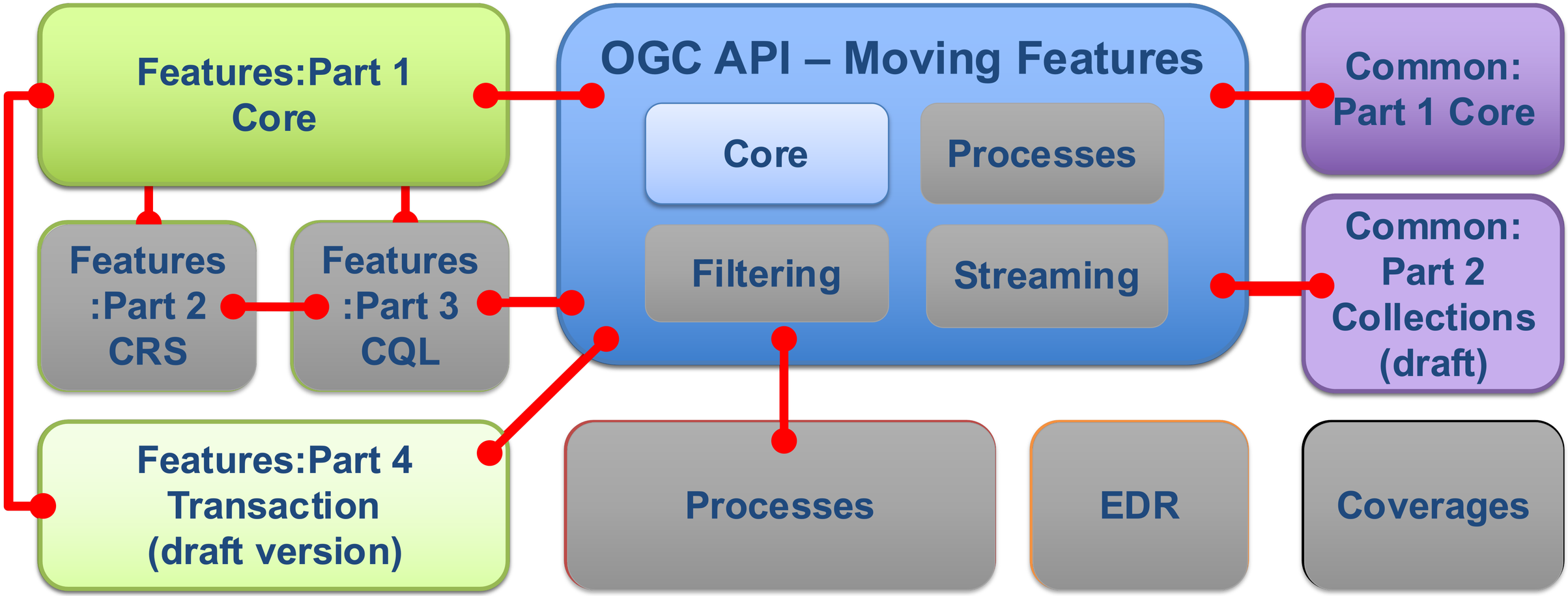
- https://docs.opengeospatial.org/is/19-045r3/19-045r3.html
- OGC MF–JSON encoding covered various cases
  - Core: MovingFeature (and MovingFeatureCollection) Object
  - Location: TemporalGeometry Object
    - Types: **MovingPoint**, **MovingLineString**, **MovingPolygon**, and **MovingPointCloud**
    - Predefined interpolations: **Discrete, Step, Linear, Quadratic,** and **Cubic**
  - Properties: TemporalProperties Object
    - Types: **Measure, Text,** and **Image**
    - Predefined interpolations: **Discrete, Step, Linear,** and **Regression**
- There are other conceptual (and encoding) models for moving features, such as OGC MF XML, CSV, netCDF, and so on;
  - But they have not fully covered various cases.

Overview of OGC API-MF

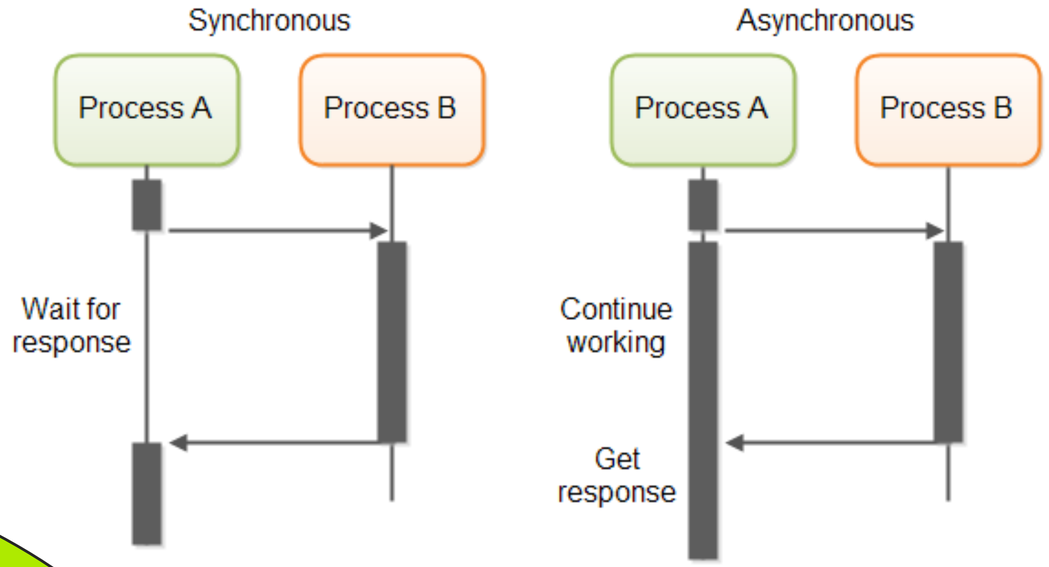
OGC API–Moving Features consists of four parts

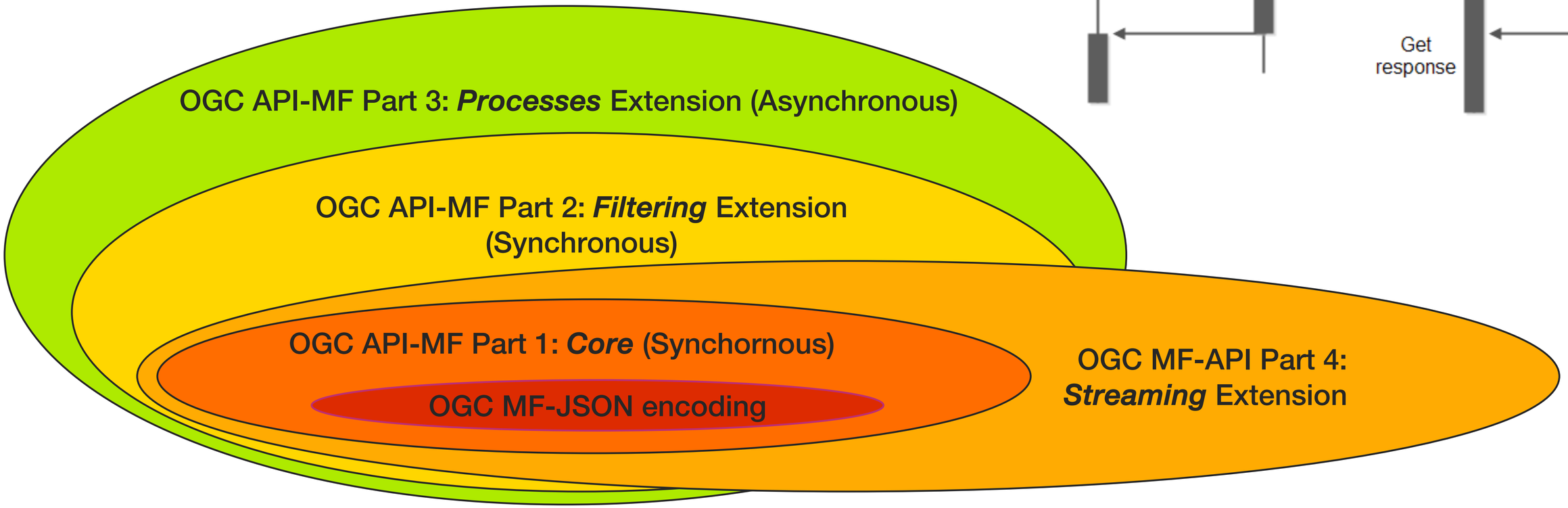
- **Part 1: Core (Features Extension)**
  - Moving feature is also a kind of feature.
    - Inherit the necessary APIs (and Resources) from OGC API-Features (& Common)
  - Consider **CRUD** operations for ***MF-JSON*** objects
    - CRUD: Create, Read, Update, and Delete
  - Support fundamental operations
    - Based on OGC Moving Features Access **Type A** operations
- Part 2: Filtering Extension
  - Based on OGC Moving Features Access **Type B&C** operations (**Synchronous**)
- Part 3: Processes Extension
  - Based on OGC Moving Features Access **Type B&C** operations (**Asynchronous**)
- Part 4: Streaming Extension
  - Consider moving features which collected real-time

Relationship with other OGC APIs



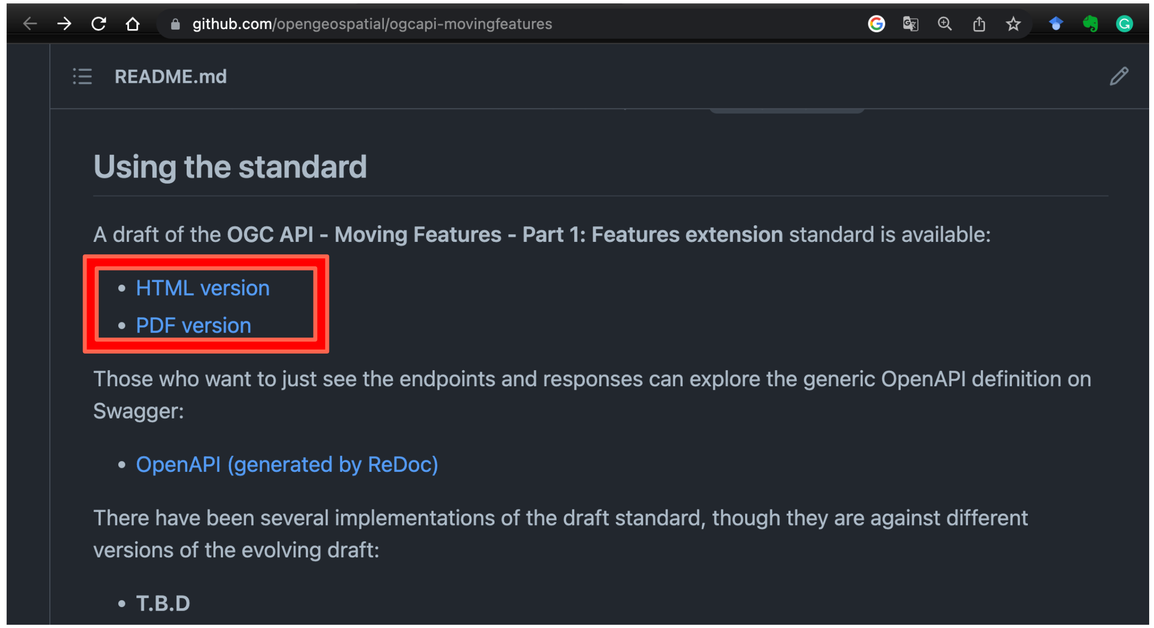
Start from the synchronous way





OGC API – Moving Features – Part 1: Core

- ***The draft version for OGC API – MF – Part 1 is finalized! (Not Standard)***
  - **Overview:**
    - https://ogcapi.ogc.org/movingfeatures/
    - https://github.com/opengeospatial/ogcapi-movingfeatures
  - **Draft document**:
    - https://opengeospatial.github.io/ogcapi-movingfeatures/standard/standard_document.html
  - **OpenAPI**:
    - https://opengeospatial.github.io/ogcapi-movingfeatures/openapi/openapi-movingfeatures-1.html



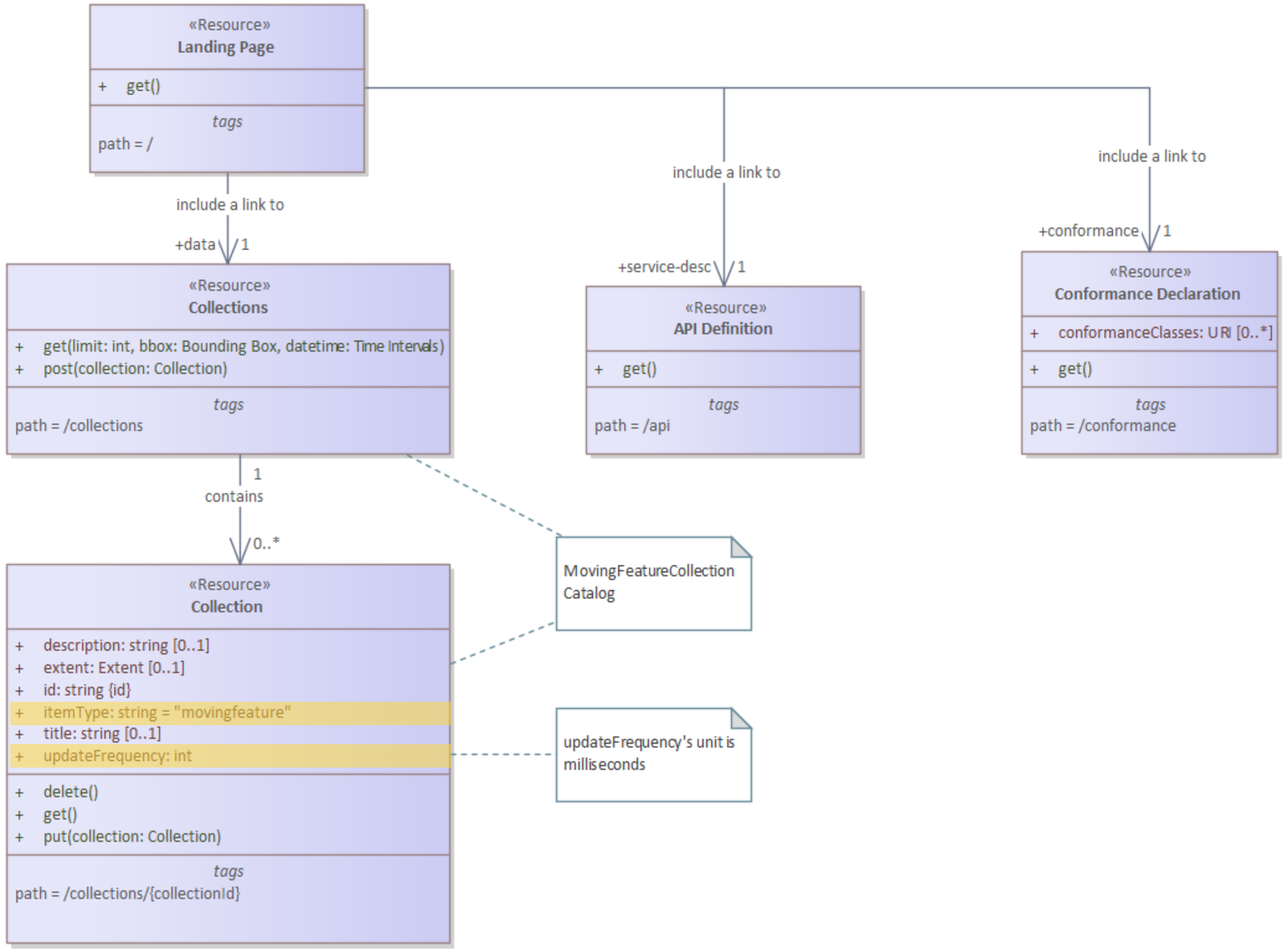
- The goal of **OGC API – Moving Features Feature extension**:
  - Provide an interface for **Creating, Retrieving, Updating,** and **Deleting *Moving Features***, which conformance to the **OGC MF-JSON encoding standard**.

Overview of OGC API – MF – Part 1:Core

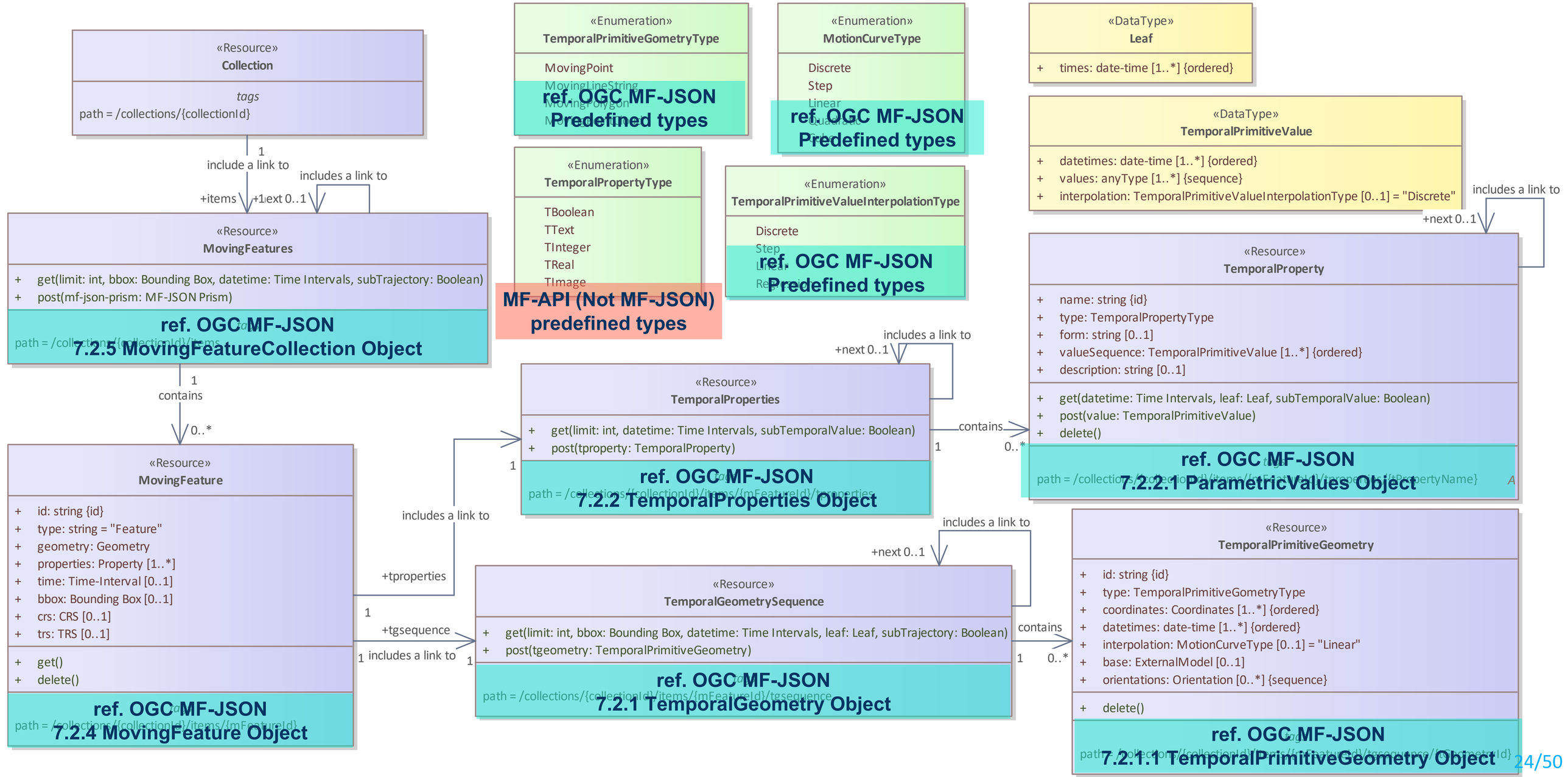
	Resource	Path	HTTP Method	Document Reference
Inherited from OGC API-Features	Landing page	/	GET	No modification
	API definition	/api	GET	
	Conformance classes	/conformance	GET	
	Collections metadata	/collections	GET, POST	7.3
	Collection instance metadata	/collections/{collectionId}	GET, DELETE, PUT	7.4
Resources from OGC MF-JSON	Moving feature collection	/collections/{collectionId}/items	GET, POST	8.3
	Moving feature instance	/collections/{collectionId}/items/{mFeatureId}	GET, DELETE	8.4
	Temporal geometry sequence	/collections/{collectionId}/items/{mFeatureId}/tgsequence	GET, POST	8.5
	Temporal primitive geometry	/collections/{collectionId}/items/{mFeatureId}/tgsequence/{tGeometryId}	DELETE	8.6
	Temporal properties	/collections/{collectionId}/items/{mFeatureId}/tproperties	GET, POST	8.8
	Temporal property instance	/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}	GET, POST, DELETE	8.9
Resources from OGC MF-Access	Velocity query	/collections/{collectionId}/items/{mFeatureId}/tgsequence/{tGeometryId}/velocity	GET	8.7
	Acceleration query	/collections/{collectionId}/items/{mFeatureId}/tgsequence/{tGeometryId}/acceleration	GET	8.7
	Distance query	/collections/{collectionId}/items/{mFeatureId}/tgsequence/{tGeometryId}/distance	GET	8.7

Inherited API-Features and Common

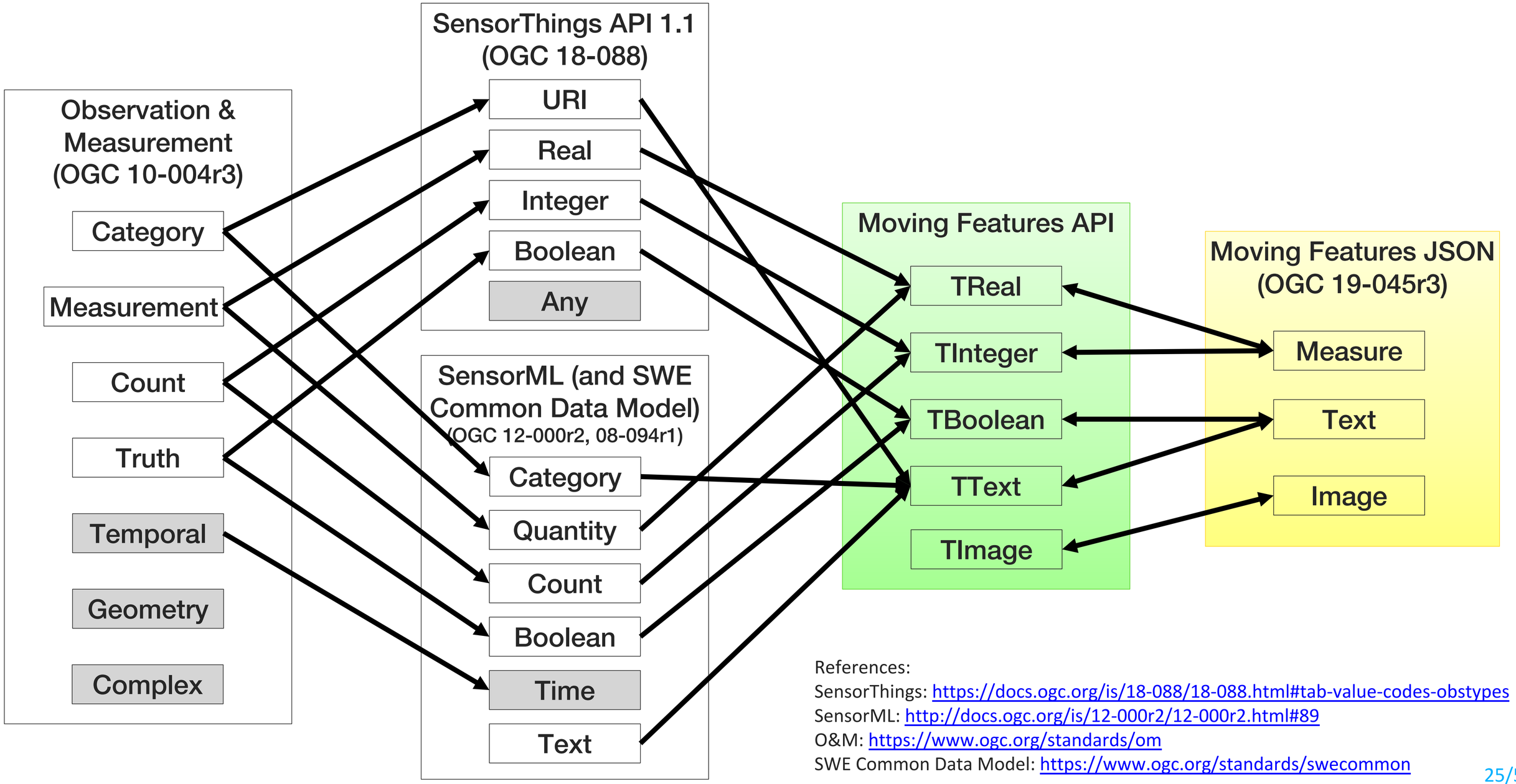
- There is **no modification** for supporting moving features.
- But there are two constraints:
  - The ***itemType*** of Collection should be "**movingfeature**"
  - The new property ***(updateFrequency***) is required to determine the continuous of temporal geometry
    - Update frequency: a time interval of sampling location



Resource diagram of OGC API – MF



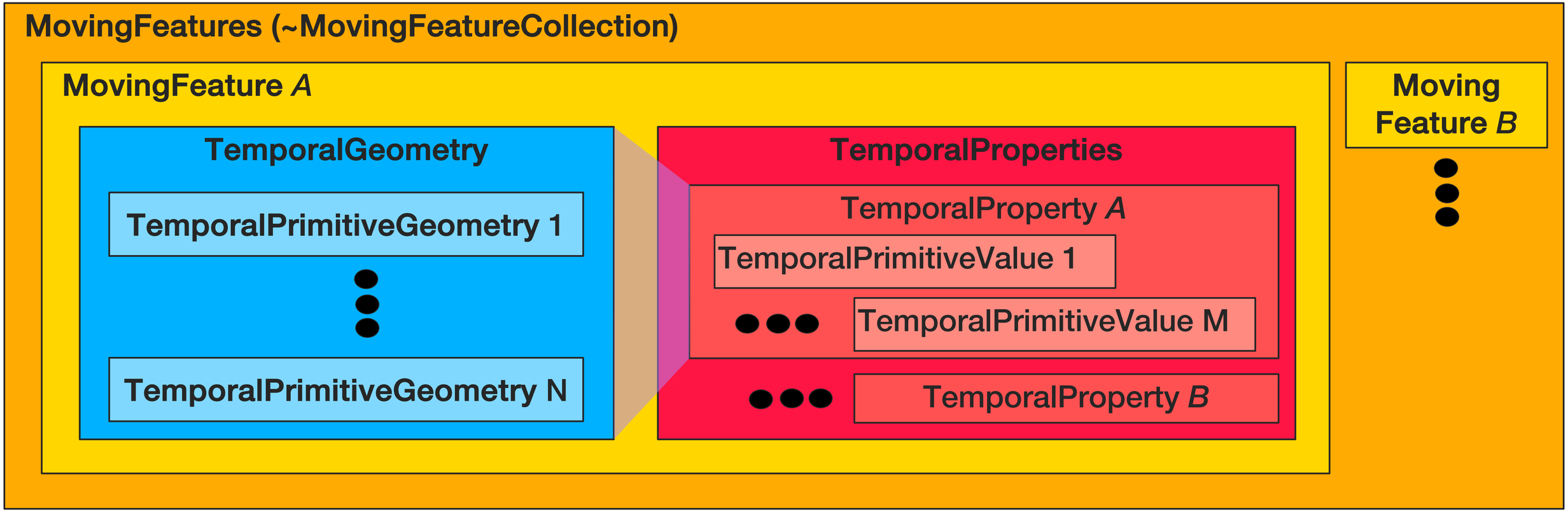
Predefined Temporal Property Types



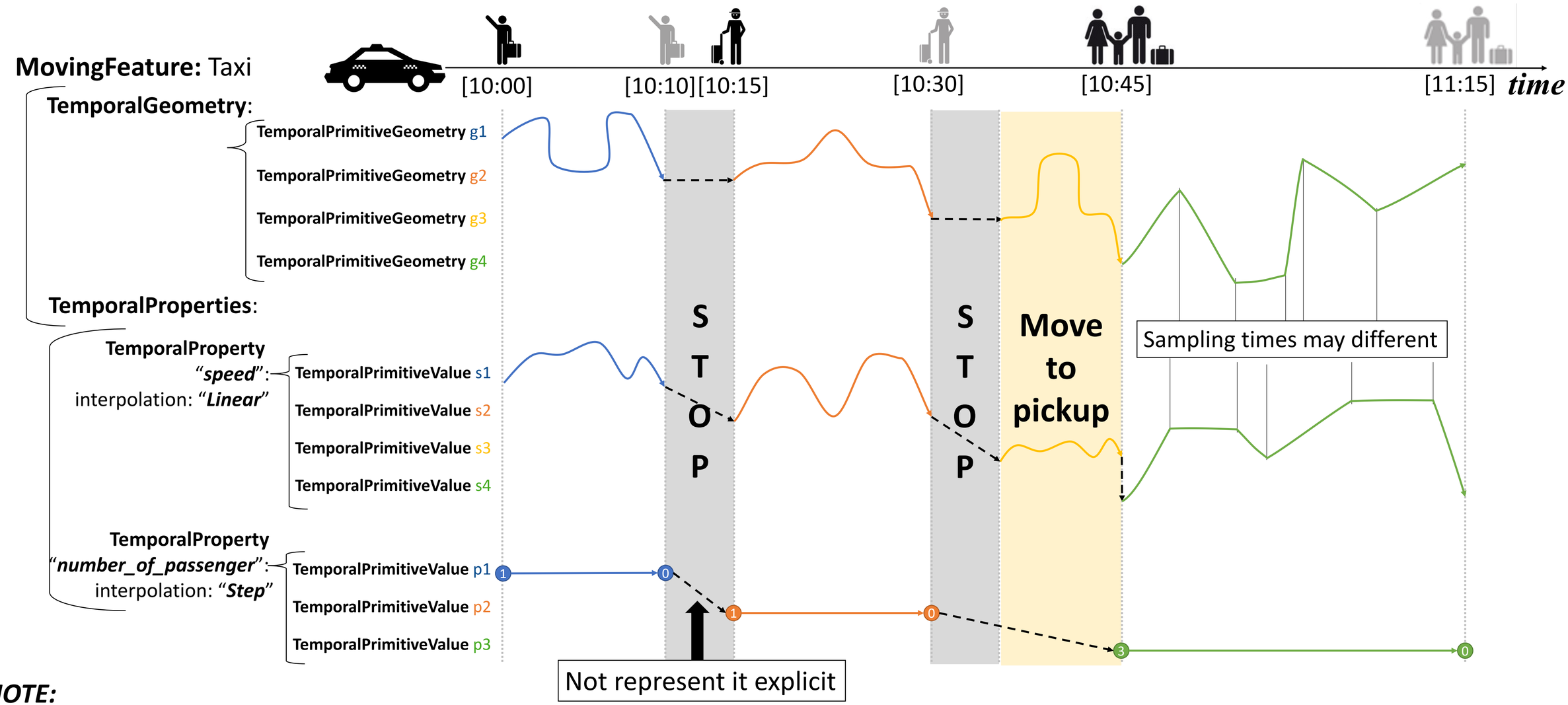
References:
SensorThings: https://docs.ogc.org/is/18-088/18-088.html#tab-value-codes-obstypes
SensorML: http://docs.ogc.org/is/12-000r2/12-000r2.html#89
O&M: https://www.ogc.org/standards/om
SWE Common Data Model: https://www.ogc.org/standards/swecommon

Relationship of Between Web Resources

- ***TemporalGeometry*** *is a kind of* ***TemporalProperty***
- ***TemporalPrimitiveGeometry*** *is a kind of* ***TemporalPrimitiveValue***



Example of Moving Feature

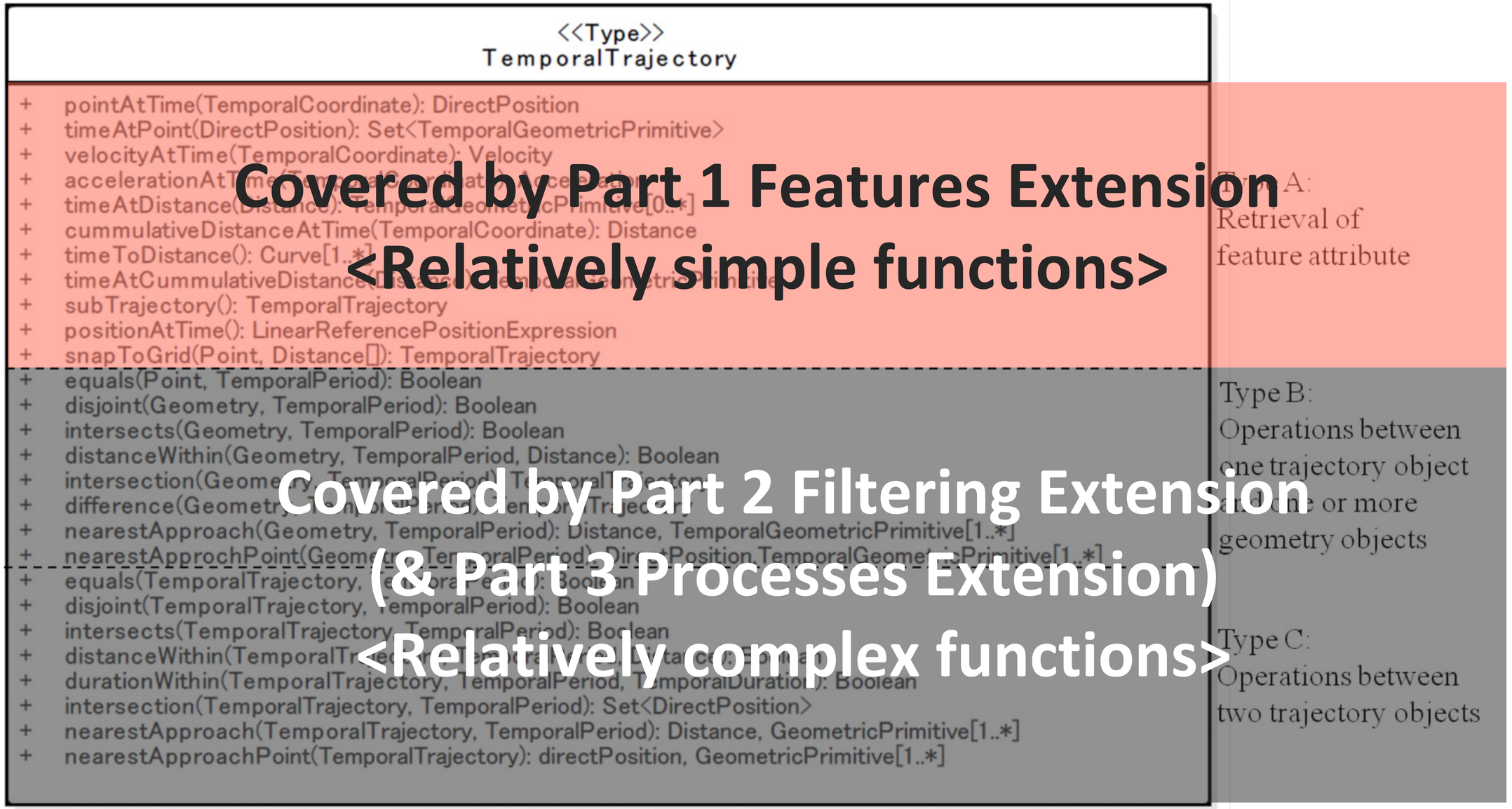


NOTE:

TemporalGeometry *is a kind of* ***TemporalProperty***

TemporalPrimitiveGeometry *is a kind of* ***TemporalPrimitiveValue***

Operations Defined in OGC MF Access



Covered by Part 1 Features Extension
<Relatively simple functions>

Covered by Part 2 Filtering Extension
(& Part 3 Processes Extension)
<Relatively complex functions>

Image source: OGC Moving Features Access http://docs.opengeospatial.org/is/16-120r3/16-120r3.html

Type A Operation List

- pointAtTime
- velocityAtTime
- accelerationAtTime
- **cummulativeDistanceAtTime**
- ~~positionAtTime~~
- ~~timeAtPoint~~
- **timeAtDistance**
- **timeToDistance**
- subTrajectory
- ~~snapToGrid~~

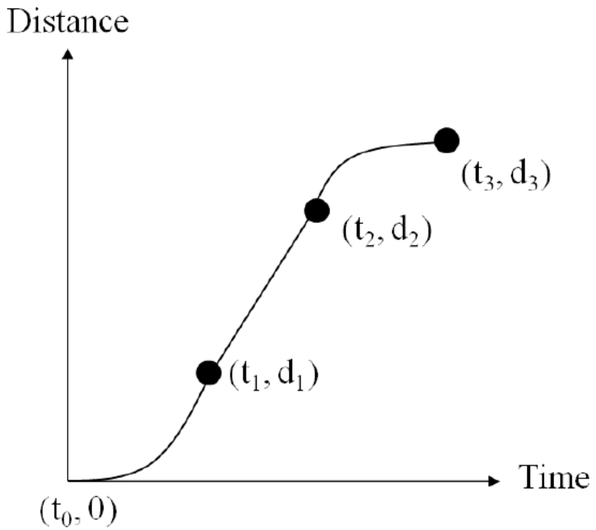


Figure 8 — Example of time to distance curve

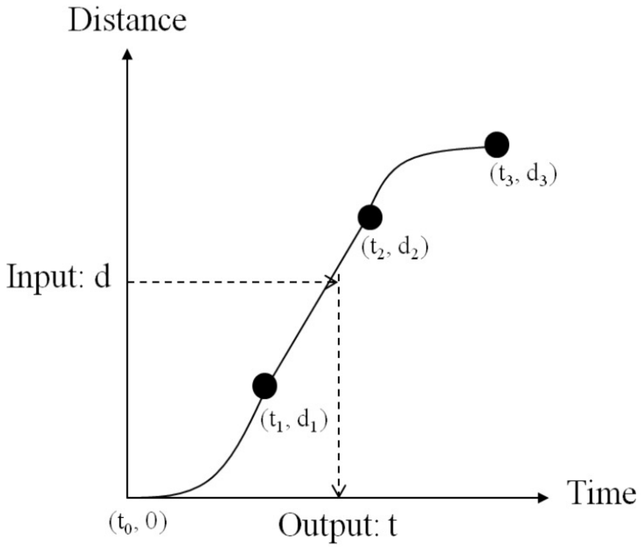


Figure 9 — Example of timeAtDistance

These operations can get results simply from the time-to-distance curve

Define Distance Resource

- a kind of TemporalProperty Resource to represent a time-to-distance curve
- derived from TemporalPrimitiveGeometry Resource

Image source: http://docs.opengeospatial.org/is/16-120r3/16-120r3.html

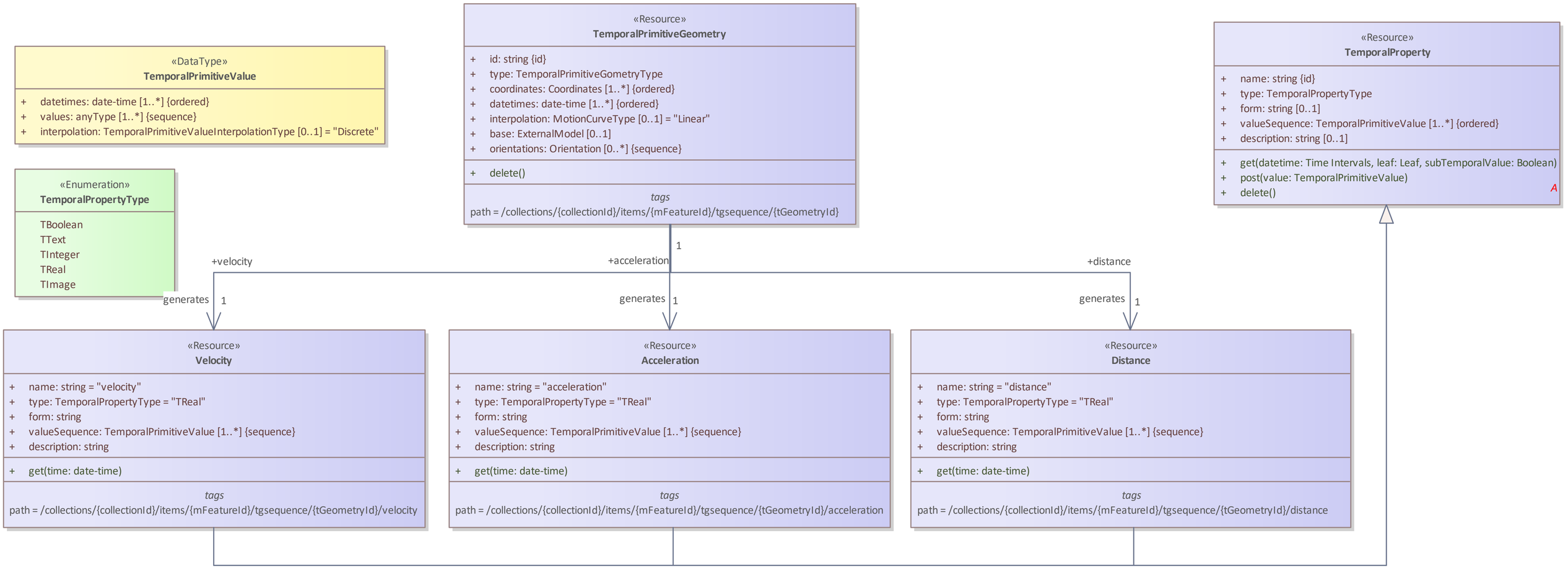
Type A Operation List

- pointAtTime
- **velocityAtTime**
- **accelerationAtTime**
- cummulativeDistanceAtTime
- ~~positionAtTime~~
- ~~timeAtPoint~~
- timeAtDistance
- timeToDistance
- subTrajectory
- ~~snapToGrid~~

Similarly, can be supported by defining Velocity (and Acceleration) Resource like the Distance resource

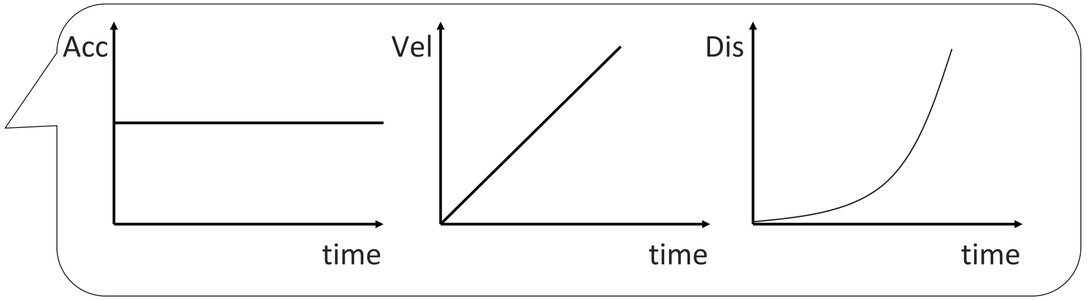
Resources for Temporal Geometry Query

- **Distance**, **Velocity**, and **Acceleration** resources support only HTTP GET operation
  - A kind of **TemporalProperty** with a specified type of value
  - The result schema is **TemporalProperties** in ***MF-JSON***



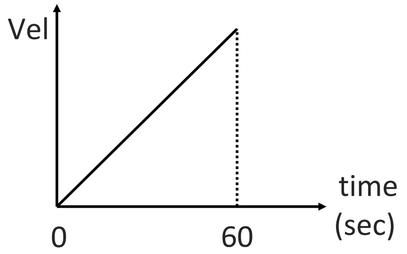
Examples with Queries

collectionId: col-1
mFeatureId: mf-1
tGeometryId: tg-1



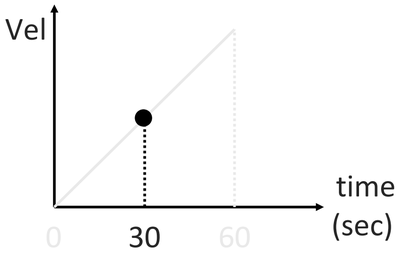
GET
/collections/col-1/items/mf-1
/tgsequence/tg-1/velocity


```
{
  "temporalproperties": [
    {
      "datetimes":
        ["2022-11-01T10:00:00Z",
        "2022-11-01T10:01:00Z"],
      "velocity": {
        "type": "Measure",
        "form": "KMH",
        "values": [0.0, 100.0],
        "interpolation": "Linear"
      }
    }
  ]
}
```

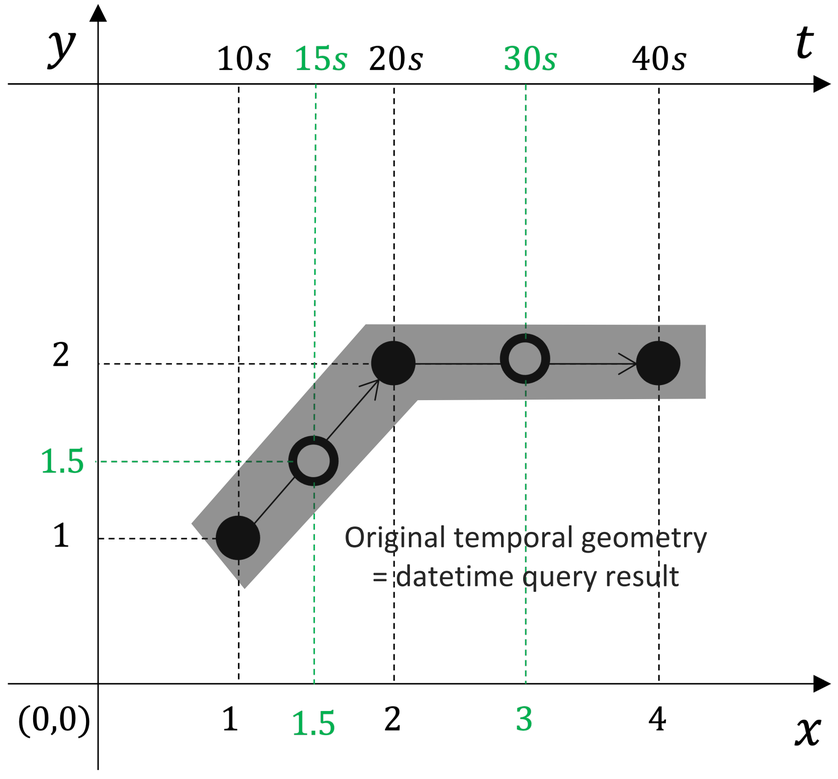
GET
/collections/col-1/items/mf-1
/tgsequence/tg-1/velocity
?datetime="2022-11-01T10:00:30"


```
{
  "temporalproperties": [
    {
      "datetimes":
        ["2022-11-01T10:00:30Z"],
      "velocity": {
        "type": "Measure",
        "form": "KMH",
        "values": [50.0],
        "interpolation": "Discretre"
      }
    }
  ]
}
```

datetime Parameter

- The parameter ‘datetime’ is defined in the OGC API – Features (and Common)
  - ‘datetime’ is a date-time string.
    - a time instance, a half-bounded time interval, and a bounded time interval
  - It returns the features intersected over time as its result.
  - This is a required parameter in the API – MF.



If datetime=
"2021-09-14T12%3A00%3A15Z%2F
2021-09-14T12%3A00%3A30Z"*; then*

<temporal primitive geometry object>

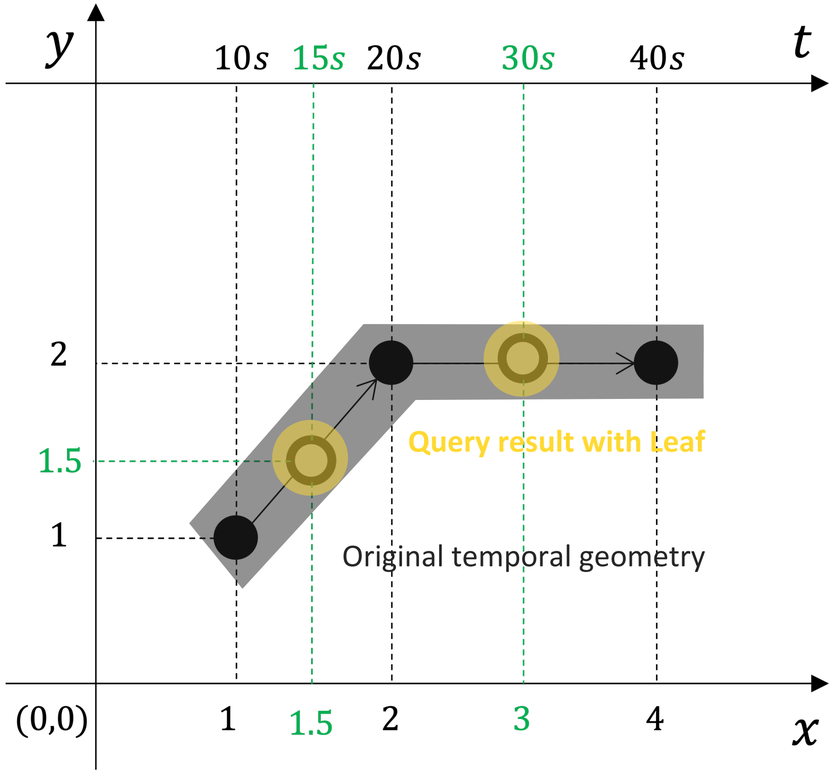
```
{
 "id": "tgeom",
 "type": "MovingPoint",
 "datetimes": [
  "2021-09-14T12:00:10Z",
  "2021-09-14T12:00:20Z",
  "2021-09-14T12:00:40Z"
 ],
 "coordinates": [
  [1,1],
  [2,2],
  [4,2]
 ],
 "interpolation": "Linear",
}
```

<tgsequencequery response>

```
...
"geometrySequence": [
 {
  "id": "tgeom",
  "type": "MovingPoint",
  "datetimes": [
   "2021-09-14T12:00:10Z",
   "2021-09-14T12:00:20Z",
   "2021-09-14T12:00:40Z"
  ],
  "coordinates": [
   [1,1],
   [2,2],
   [4,2]
  ],
  "interpolation": "Linear",
 },
...
```

leaf Parameter

- The parameter 'leaf' can be used in the HTTP GET operation of **TemporalGeometrySequence** and **TemporalProperty**
  - 'leaf' is a sequence of date-time strings (i.e., an array of date-time strings).
  - Implements ***pointAtTime*** operation in the OGC Moving Feature Access standard



<temporal primitive geometry object>

```
{
 "id": "tgeom",
 "type": "MovingPoint",
 "datetimes": [
  "2021-09-14T12:00:10Z",
  "2021-09-14T12:00:20Z",
  "2021-09-14T12:00:40Z"
 ],
 "coordinates": [
  [1,1],
  [2,2],
  [4,2]
 ],
 "interpolation": "Linear",
}
```

If datetime= "2021-09-14T12%3A00%3A15Z%2F 2021-09-14T12%3A00%3A30Z", ***then***

<tgsequencequery response>

```
...
"geometrySequence": [
 {
  "id": "tgeom",
  "type": "MovingPoint",
  "datetimes": [
   "2021-09-14T12:00:10Z",
   "2021-09-14T12:00:20Z",
   "2021-09-14T12:00:40Z"
  ],
  "coordinates": [
   [1,1],
   [2,2],
   [4,2]
  ],
  "interpolation": "Linear",
 },
...
```

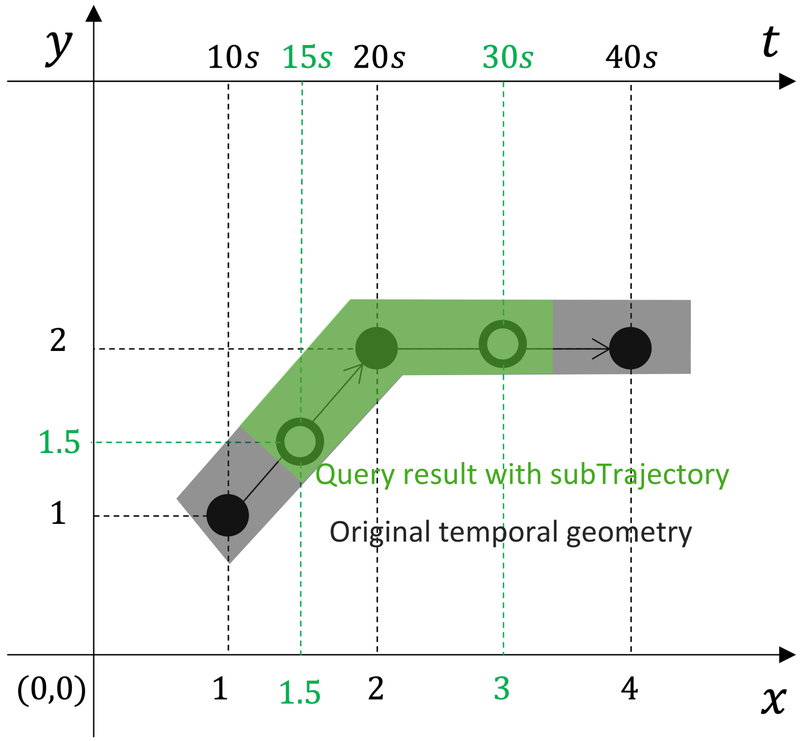
If leaf=["2021-09-14T12:00:15Z", "2021-09-14T12:00:30Z"], ***then***

<tgsequencequery response>

```
...
"geometrySequence": [
 {
  "id": "tgeom",
  "type": "MovingPoint",
  "datetimes": [
   "2021-09-14T12:00:15Z",
   "2021-09-14T12:00:30Z"
  ],
  "coordinates": [
   [1.5,1.5],
   [3,2]
  ],
  "interpolation": "Discrete",
 },
...
```

subTrajectory (and subTemporalValue) Parameter

- The parameter 'subTrajectory' can be used in the HTTP GET operation of **MovingFeatures** and **TemporalGeometrySequence**
  - 'subTrajectory' has a Boolean. A specified time interval is derived from the 'datetime' parameter.
  - Implements ***subTrajectory*** operation in the OGC Moving Feature Access standard.
  - Similarly, for **TemporalProperties**, there is a 'subTemporalValue' parameter.



If datetime= "2021-09-14T12%3A00%3A15Z%2F 2021-09-14T12%3A00%3A30Z", *then*

<temporal primitive geometry object>

```
{
 "id": "tgeom",
 "type": "MovingPoint",
 "datetimes": [
  "2021-09-14T12:00:10Z",
  "2021-09-14T12:00:20Z",
  "2021-09-14T12:00:40Z"
 ],
 "coordinates": [
  [1,1],
  [2,2],
  [4,2]
 ],
 "interpolation": "Linear",
}
```

<items query response>

```
...
"temporalGeometry":
 {
  "id": "tgeom",
  "type": "MovingPoint",
  "datetimes": [
   "2021-09-14T12:00:10Z",
   "2021-09-14T12:00:20Z",
   "2021-09-14T12:00:40Z"
  ],
  "coordinates": [
   [1,1],
   [2,2],
   [4,2]
  ],
  "interpolation": "Linear",
 },
...
```

If subTrajectory = true *and* datetime= "2021-09-14T12%3A00%3A15Z%2F 2021-09-14T12%3A00%3A30Z", *then*

<items query response>

```
...
"temporalGeometry":
 {
  "id": "tgeom",
  "type": "MovingPoint",
  "datetimes": [
   "2021-09-14T12:00:15Z",
   "2021-09-14T12:00:20Z",
   "2021-09-14T12:00:30Z"
  ],
  "coordinates": [
   [1.5,1.5],
   [2,2],
   [3,2]
  ],
  "interpolation": "Linear ",
 },
...
```

Example GET /collections response


```
{
  "collections": [
    {
      "id": "mfc-1",
      "title": "MovingFeatureCollection_1",
      "description": "a collection of moving features to manage data in a distinct (physical or logical)
space",
      "itemType": "movingfeature",
      "updateFrequency": 1000,
      "extent": {
        "spatial": {
          "bbox": [
            -180, -90, 190, 90
          ],
          "crs": "http://www.opengis.net/def/crs/OGC/1.3/CRS84"
        },
        "temporal": {
          "interval": [
            "2011-11-11T12:22:11Z","2012-11-24T12:32:43Z"
          ],
          "trs": "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian"
        }
      },
      "links": [
        {
          "href": "https://data.example.org/collections/mfc-1",
          "rel": "self",
          "type": "application/json"
        }
      ]
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections",
      "rel": "self",
      "type": "application/json"
    }
  ]
}
```


Special member for MovingFeature

Collection Resource Instance
→ GET /collections/mfc-1 response

We can get FeatureCollection in the Server
(Collection of the MovingFeatureCollection)
This work is mainly supported by OGC API - Features.

Example GET /collections/{cid}/items response

mfc-1

We can get MovingFeatureCollection for Collection “mfc-1”
(List of the static information of the moving feature)
(Does not include TemporalGeometry and TemporalProperties)


```
{
  "type": "FeatureCollection",
  "features":[
    {
      "id": "mf-1",
      "type": "Feature",
      "geometry":{
        "type": "LineString",
        "coordinates": [
          [139.757083, 35.627701, 0.5],
          [139.757399, 35.627701, 2.0],
          [139.757555, 35.627688, 4.0],
          [139.757651, 35.627596, 4.0],
          [139.757716, 35.627483, 4.0]
        ]
      },
      "properties":{
        "name": "car1",
        "state": "test1",
        "video": "http://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/video.mpeg"
      },
      "bbox":[
        139.757083, 35.627483, 0.0,
        139.757716, 35.627701, 4.5
      ],
      "time":[
        "2011-07-14T22:01:01Z",
        "2011-07-15T01:11:22Z"
      ],
      "crs": {
        "type": "Name",
        "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
      },
      "trs": {
        "type": "Name",
        "properties": "urn:ogc:data:time:iso8601"
      }
    }
  ],
```


MovingFeature Resource Instance
→ GET /collections/mfc-1/items/mf-1 response
→ Almost the same schema as *MovingFeature* object in MF-JSON


```
  "crs": {
    "type": "Name",
    "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
  },
  "trs": {
    "type": "Name",
    "properties": "urn:ogc:data:time:iso8601"
  },
  "links":[
    {
      "href": "https://data.example.org/collections/mfc-1/items",
      "rel": "self",
      "type": "application/geo+json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items&offset=1&limit=1",
      "rel": "next",
      "type": "application/geo+json"
    }
  ],
  "timeStamp": "2020-01-01T12:00:00Z",
  "numberMatched": 100,
  "numberReturned": 1
}
```

Example GET /collections/{cid}/items with *subTrajectory* parameter

mfc-1 =true

When using the *subTrajectory* query parameter as "true" with a GET operation, we can get MovingFeatureCollection with TemporalGeometry for Collection “mfc-1”


```
{
  "type": "FeatureCollection",
  "features":[
    {
      "id": "mf-1",
      "type": "Feature",
      "temporalGeometry": {
        "type": "MovingPoint",
        "datetimes": ["2011-07-14T22:01:01Z", "2011-07-14T22:01:02Z", "2011-07-14T22:01:03Z",
"2011-07-14T22:01:04Z", "2011-07-14T22:01:05Z"],
        "coordinates": [
          [139.757083, 35.627701, 0.5],
          [139.757399, 35.627701, 2.0],
          [139.757555, 35.627688, 4.0],
          [139.757651, 35.627596, 4.0],
          [139.757716, 35.627483, 4.0]
        ],
        "interpolation": "Linear"
      },
      "properties":{
        "label": "car",
        "state": "test1",
        "video": "http://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/video.mpeg"
      },
      "bbox":[
        139.757083, 35.627483, 0.0,
        139.757716, 35.627701, 4.5
      ],
      "time":[
        "2011-07-14T22:01:01Z",
        "2011-07-15T01:11:22Z"
      ],
      "crs": {
        "type": "Name",
        "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
      },
      "trs": {
        "type": "Name",
        "properties": "urn:ogc:data:time:iso8601"
      }
    }
```


subTrajectory = true, then the respose include “temporalGeometry”

same schema as *MovingFeature* object in MF-JSON


```
  "crs": {
    "type": "Name",
    "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
  },
  "trs": {
    "type": "Name",
    "properties": "urn:ogc:data:time:iso8601"
  },
  "links":[
    {
      "href": "https://data.example.org/collections/mfc-1/items",
      "rel": "self",
      "type": "application/geo+json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items&offset=1&limit=1",
      "rel": "next",
      "type": "application/geo+json"
    }
  ],
  "timeStamp": "2020-01-01T12:00:00Z",
  "numberMatched": 100,
  "numberReturned": 1
}
```

Example GET /collections/{cid}/items/{mid}/tgsequence

mfc-1 mf-1


```
{
  "type": "TemporalGeometrySequence",
  "geometrySequence": [
    {
      "id": "tg-1",
      "type": "MovingPoint",
      "datetimes": [
        "2011-07-14T22:01:02Z",
        "2011-07-14T22:01:03Z",
        "2011-07-14T22:01:04Z"
      ],
      "coordinates": [
        [139.757399, 35.627701, 2.0],
        [139.757555, 35.627688, 4.0],
        [139.757651, 35.627596, 4.0]
      ],
      "interpolation": "Linear",
      "base": {
        "type": "glTF",
        "href":
"https://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/car3dmodel.gltf"
      },
      "orientations":[
        {
          "scales": [1,1,1],
          "angles": [0,355,0]
        },
        {
          "scales": [1,1,1],
          "angles": [0,0,330]
        },
        {
          "scales": [1,1,1],
          "angles": [0,0,300]
        }
      ],
      "crs": {
        "type": "Name",
        "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
      },
      "trs": {
        "type": "Name",
        "properties": "urn:ogc:def:trs:OGC:1.0:ModelingCoordinateSystem"
      }
    }
  ],
```


We can get TemporalGeometrySequence for MovingFeature “mf-1”
(Sequence of the temporal primitive geometry with timestamps)

TemporalPrimitiveGeometry Resource Instance
→ GET /collections/mfc-1/items/mf-1/tgsequence/tg-1 response
→ same schema as the *TemporalPrimitiveGeometry* object in MF-JSON


```
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tgsequence",
      "rel": "self",
      "type": "application/json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-
1/tgsequence&offset=10&limit=1",
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 100,
  "numberReturned": 1
}
```

Example GET /collections/{cid}/items/{mid}/tproperties

mfc-1 **mf-1**


```
{
  "temporalProperties": [
    {
      "name": "length",
      "type": "TReal",
      "form": "http://www.qudt.org/qudt/owl/1.0.0/quantity/Length"
    },
    {
      "name": "speed",
      "type": "TReal",
      "form": "KHM"
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tproperties",
      "rel": "self",
      "type": "application/json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tproperties&offset=2&limit=2",
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 10,
  "numberReturned": 2
}
```


We can get TemporalProperties for MovingFeature “mf-1”
(List of the metadata of temporal property)
(Doesn’t include temporal property values)
(Not the same as *TemporalProperties* object in MF-JSON)

Example GET /collections/{cid}/items/{mid}/tproperties with *subTemporalValue* query parameter

=true


```
{
  "temporalProperties": [
    {
      "datetimes": ["2011-07-14T22:01:06.000Z", "2011-07-14T22:01:07.000Z", "2011-07-14T22:01:08.000Z"],
      "length": {
        "type": "Measure",
        "form": "http://www.qudt.org/qudt/owl/1.0.0/quantity/Length",
        "values": [1.0, 2.4, 1.0],
        "interpolation": "Linear"
      },
      "speed" : {
        "type" : "Measure",
        "form" : "KMH",
        "values" : [65.0, 70.0, 80.0],
        "interpolation": "Linear"
      }
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tproperties",
      "rel": "self",
      "
    },
    {
      "
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 10,
  "numberReturned": 2
}
```


TemporalProperties object in MF-JSON

When using the *subTemporalValue* query parameter as "true" with a GET operation, we can get TemporalProperties with temporal property values for MovingFeature “mf-1”

Example GET /collections/{cid}/items/{mid}/tproperties/{name}

mfc-1 mf-1 speed


```
{
  "temporalProperties": [
    {
      "datetimes":[
        "2011-07-14T22:01:02Z",
        "2011-07-14T22:01:03Z",
        "2011-07-14T22:01:04Z"
      ],
      "values":[
        65.0,
        70.0,
        80.0
      ],
      "interpolation": "Linear"
    },
    {
      "datetimes":[
        "2011-07-15T08:00:00Z",
        "2011-07-15T08:00:01Z",
        "2011-07-15T08:00:02Z"
      ],
      "values":[
        0.0,
        20.0,
        50.0
      ],
      "interpolation": "Linear"
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tproperties/speed",
      "rel": "self",
      "type": "application/json"
    }
  ]
}
```


We can get a sequence of the temporal primitive value for TemporalProperty “speed”


Implementations for MF-JSON and API-MF

OGC MF-JSON supported open-sources

- **OGC MF-JSON** supported open-sources
  - For visualization
    - **STINUUM** (https://github.com/aistairc/mf-cesium)
      - A space-time visual analysis tool of moving objects with Cesium
  - For spatio-temporal operation
    - **MobilityDB (**https://github.com/MobilityDB/MobilityDB)
      - An open-source geospatial trajectory data management & analysis platform
    - **MovingPandas (**https://github.com/anitagraser/movingpandas)
      - Implementation of Trajectory classes and functions built on top of GeoPandas

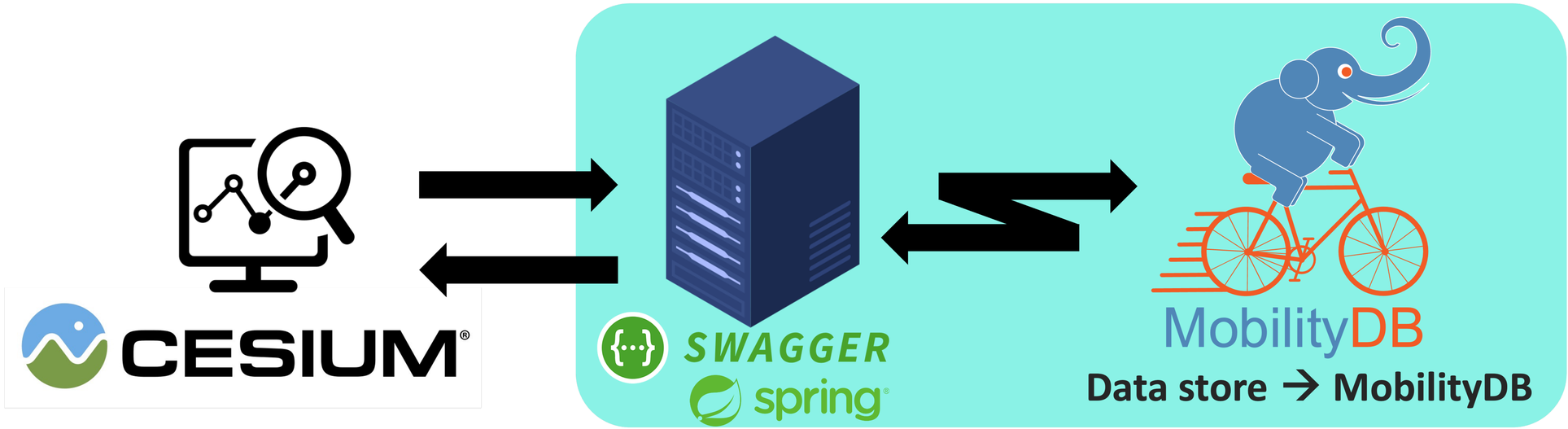
OGC MF-JSON supported open-sources

- **MobilityDB (**https://github.com/MobilityDB/MobilityDB**)**
  - Support import and export functions with MF-JSON
    - Export:
      - asMFJSON(tpoint,options=0,flags=0,maxdecdigits=15) → bytea
    - Import:
      - tgeompointFromMFJSON(text) → tgeompoint
      - tgeogpointFromMFJSON(text) → tgeogpoint
  - https://mobilitydb.github.io/MobilityDB/master/ch08.html#tpoint_inout
- **MovingPandas (**https://github.com/anitagraser/movingpandas**)**
  - Support import function from MF-JSON
    - read_mf_json(json_file_path, traj_id_property=None, traj_id=0):
  - https://github.com/movingpandas/movingpandas/blob/main/movingpandas/io.py

```
150  def read_mf_json(json_file_path, traj_id_property=None, traj_id=0):
151      """
152      Reads OGC Moving Features Encoding Extension JSON files.
153      MovingFeatures files are turned into Trajectory objects.
154      MovingFeatureCollection files are turned into TrajectoryCollection objects.
155      More info: http://www.opengis.net/doc/BP/mf-json/1.0
156
157      Parameters
158      ----------
159      json_file_path : str
160          Path to the JSON file
161      traj_id_property : str
162          Name of the MovingFeature JSON property to be used as trajectory ID
163      traj_id : any
164          Trajectory ID value to be used if no traj_id_property is supplied
165
166      Returns
167      -------
168      Trajectory or TrajectoryCollection
169      """
170      with open(json_file_path, "r") as f:
171          data = json.loads(f.read())
172      return read_mf_dict(data, traj_id, traj_id_property)
```

Implementations for OGC API – MF

- Using **OGC MF-JSON** supported open-sources
- **MF API-Server** (Opensource): implement using **pygeoapi**
  - Using **MobilityDB (and PyMEOS)** for data storage (in MF-JSON format).



1. STINUUM with MF-API

2. MF-API Server (opened as open-source)

AIST

AIST

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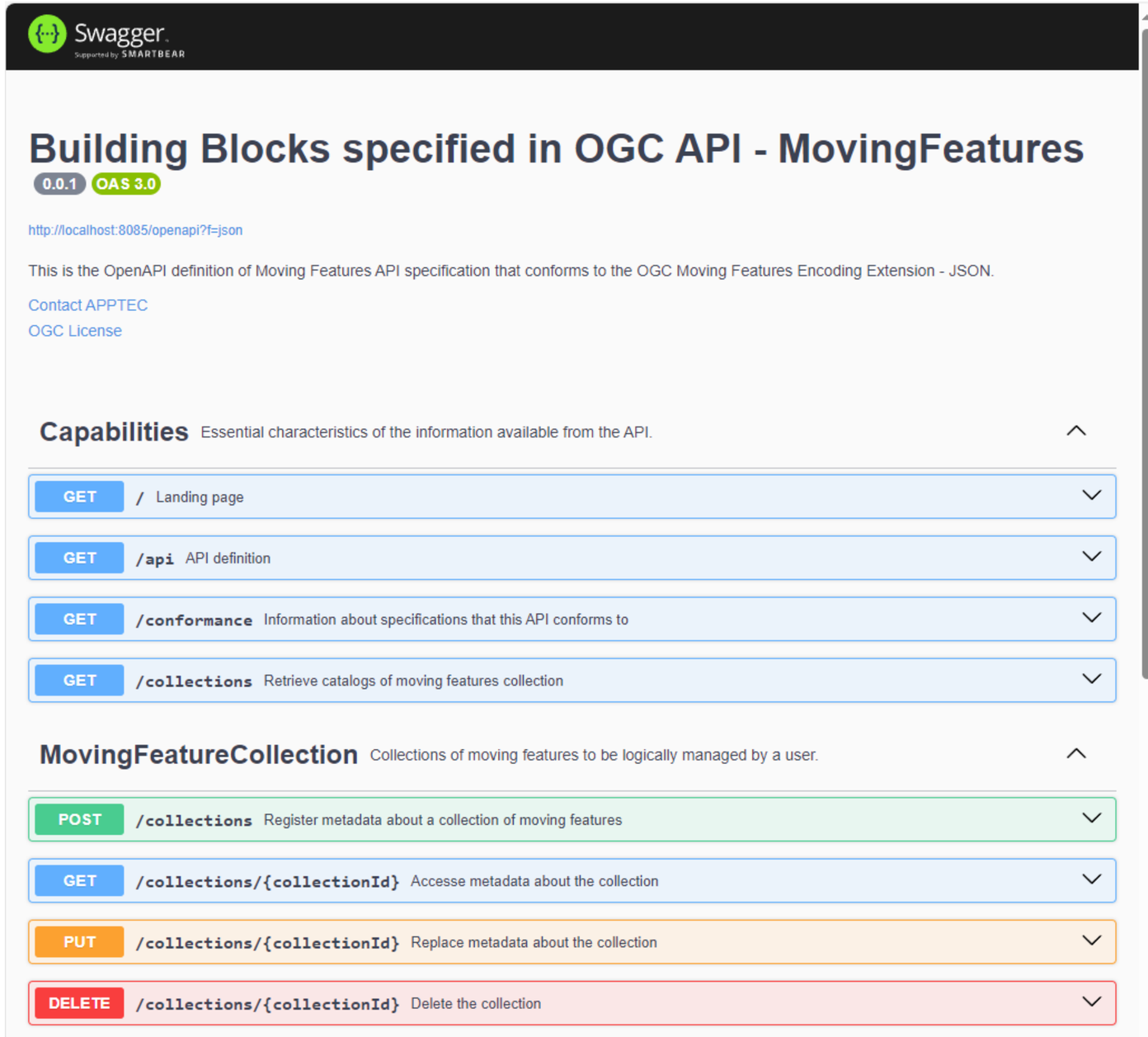
MF-API Server

- https://github.com/aistairc/mf-api
- Implement mandatory functionality for OGC API-MF
  - Except for temporal geometry query parts
    - Distance, Velocity, and Acceleration
- Easily test OGC API-MF with Swagger
- Let's practice it out in a bit!



OGC API-MF with MF-API Server

Currently Implemented

	Resource	Path	HTTP Method	Document Reference
Inherited from OGC API-Features	Landing page	/	GET	No modification
	API definition	/api	GET	
	Conformance classes	/conformance	GET	
	Collections metadata	/collections	GET, POST	7.3
	Collection instance metadata	/collections/{collectionId}	GET, DELETE, PUT	7.4
Resources from OGC MF-JSON	Moving feature collection	/collections/{collectionId}/items	GET, POST	8.3
	Moving feature instance	/collections/{collectionId}/items/{mFeatureId}	GET, DELETE	8.4
	Temporal geometry sequence	/collections/{collectionId}/items/{mFeatureId}/tgeometries	GET, POST	8.5
	Temporal primitive geometry	/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}	DELETE	8.6
	Temporal properties	/collections/{collectionId}/items/{mFeatureId}/tproperties	GET, POST	8.8
	Temporal property instance	/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}	GET, POST, DELETE	8.9
Resources from OGC MF-Access	Velocity query	/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/velocity	GET	8.7
	Acceleration query	/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/acceleration	GET	8.7
	Distance query	/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/distance	GET	8.7

Example: Inserts moving features

A user SHOULD insert a set of moving features or a moving feature into a collection with id `collectionId`.

The request body schema SHALL follows the MovingFeature object (and MovingFeatureCollection object) in the OGC MF-JSON.

Parameters | Cancel | Reset

Name	Description
collectionId * required string *(path)*	local identifier of a collection a01a5339-673a-415d-9113-0acddfe951

Request body: application/json

```
{
    "type": "Feature",
    "crs" : {
      "type": "Name",
      "properties": {"name": "urn:ogc:def:crs:OGC:1.3:CRS84"}
    },
    "trs" : {
      "type": "Link",
      "properties": {
          "type": "OGCDEF",
          "href": "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian"
      }
    },
    "temporalGeometry": {
        "type": "MovingPoint",
        "datetimes": ["2011-07-14T22:01:01Z", "2011-07-14T22:01:02Z", "2011-07-14T22:01:03Z", "2
        "coordinates": [ [139.757083, 35.627701, 0.5], [139.757399, 35.627701, 2.0], [139.757555,
        "interpolation": "Linear",
        "base": {
          "type": "xITE"
```

Predefined schema:
MF-JSON MovingFeature object

Execute

Request & Response

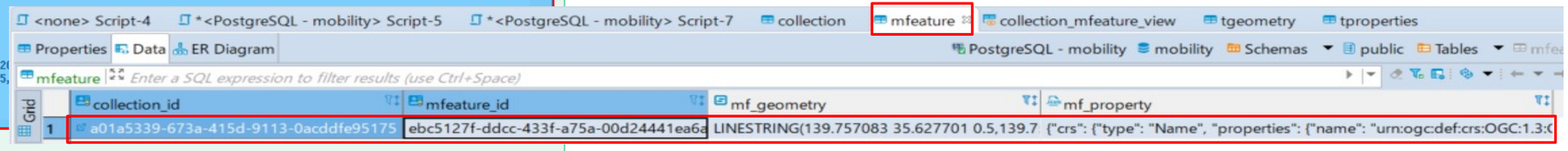
Request URL

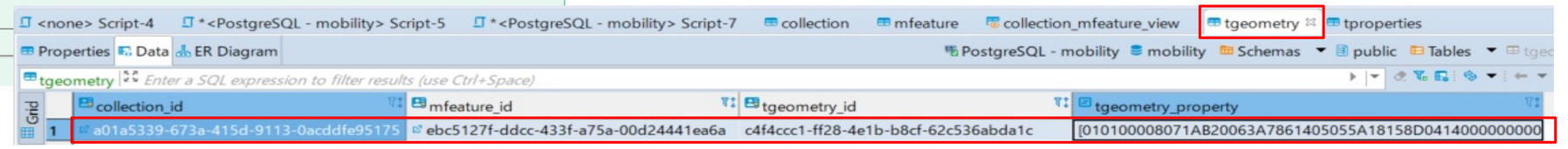
```
http://172.23.145.103:5000/collections/28a4d8df-1a0d-4577-9c06-57b7a0c5a473/items
```

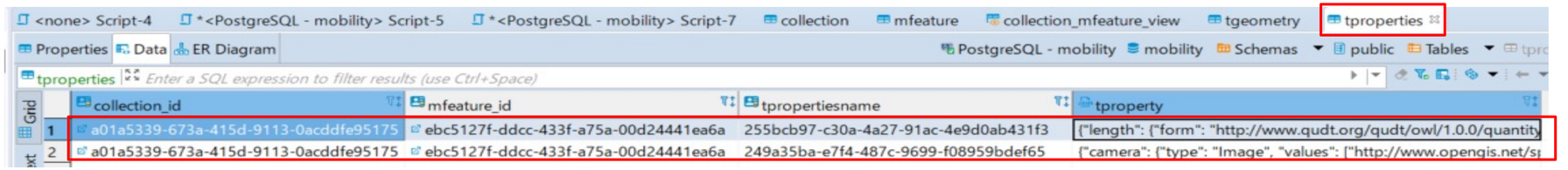
Server response

Code	Details
201	Response headers

```
access-control-allow-origin: http://172.23.145.103:5000
connection: close
content-language: en-US
content-length: 0
content-type: application/json
date: Thu,26 Jan 2023 04:41:23 GMT
location: http://172.23.145.103:5000/collections/28a4d8df-1a0d-4577-9c06-57b7a0c5a473/items/5fba5b34-cd3e-45b9-ab27-2a73664c8f3f
server: Werkzeug/2.2.2 Python/3.7.16
vary: Origin
x-powered-by: pygeoapi 0.14.dev0
```



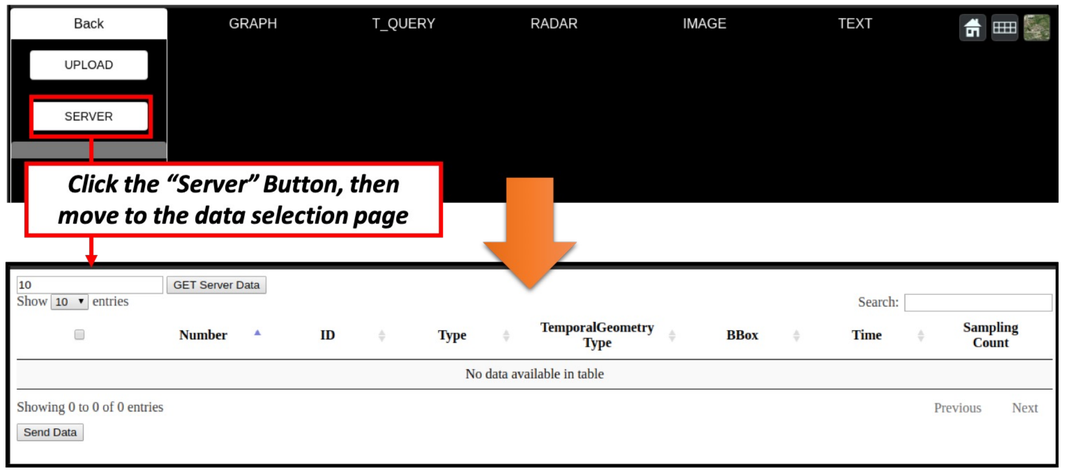


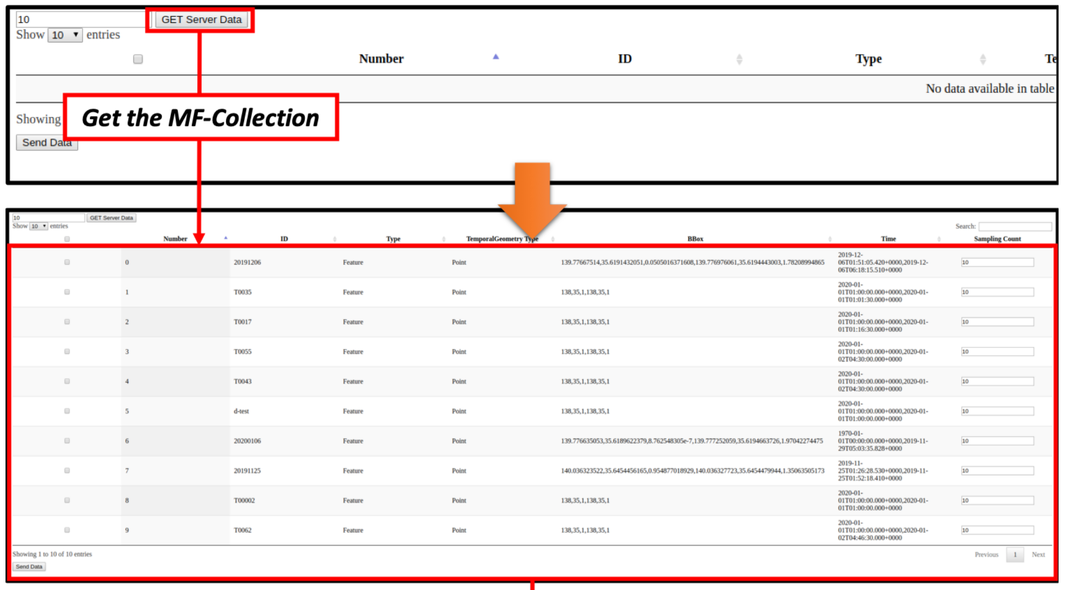


Database (with MobilityDB)

STINUUM with MF-API

- We modified STINUUM for using API-MF
- Let's practice it out in a bit!





Result of getting MF-Collection

Thank You

Community

500+ International Members

110+ Member Meetings

60+ Alliance and Liaison partners

50+ Standards Working Groups

45+ Domain Working Groups

25+ Years of Not for Profit Work

10+ Regional and Country Forums

Innovation

120+ Innovation Initiatives

380+ Technical reports

Quarterly Tech Trends monitoring

Standards

65+ Adopted Standards

300+ products with 1000+ certified implementations

1,700,000+ Operational Data Sets

Using OGC Standards