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Introduction to IoT Agent integration with NGSI-LD

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Learning Goals

- Review: What is an IoT Agent:
  - Why do you need them?
  - How do they work with NGSI?
- **NGSI-LD** Measures
- **NGSI-LD** Actuations + Lazy Attributes:
  - Registrations
  - Subscriptions
- Provisioning **NGSI-LD** Devices:
  - Data Models and **NGSI-LD** **`@context`**
  - The role of metadata
  - GeoJSON and GPS device provisioning
- Combining **NGSI-v2** Devices with an **NGSI-LD** Context Broker

What is an IoT Agent?

- **IoT Agents** overcome common problems in the IoT domain:
  - How can I translate my received measurements into a common standard regardless of the device used?
  - How can I abstract my communications so the users are able to remain unaware of the device specific protocols?
  - How can I map data received in a meaningful manner?
- An **IoT Agent** translates an IoT specific protocol into **NSGI (v2** or **LD)**
- Any class of devices with an existing IoT Agent can be considered as **FIWARE-Ready** device
- For unsupported protocols you can build your own agent.
- You only need an IoT Agent if your devices can’t support **NGSI** interfaces directly

NGSI-LD - Why Linked Data?

My data is useful to me, but is more powerful shared with others

… but what about Conway's law?

Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure.

— Melvin E. Conway

… how can I share data and benefit from other organizations if their organization *"communicates"* differently?

Illustrative NGSI-LD Use Cases

Car Parking

Cross-border Tourism

NGSI Linked Data use cases typically involve context data exchange between disparate organizations

Configuring an NGSI-LD IoT Agent

Environment Variables

- **IOTA_CB_NGSI_VERSION = "LD"**
- **IOTA_TIMESTAMP = "true"**
- **IOTA_FALLBACK_TENANT**
  equivalent to fiware-service
- **IOTA_FALLBACK_PATH**
  equivalent to fiware-service-path
- **IOTA_JSON_LD_CONTEXT**
  path to **@context** file (either a single file or an array of files)

config.js

```
contextBroker: {
    host: '192.168.1.1',
    port: '1026',
    ngsiVersion: 'ld',
    jsonLdContext: 'http://context.json-ld',
    fallbackTenant: 'openiot',
    fallbackPath: '/',
}
```

NGSI-LD @context

```
{
  "@context": [
        "https://example.com/data-models/context.jsonld",
        "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld"
    ]
}
```

A linked data **@context** is mandatory for NGSI-LD,and should be made available publicly.

NGSI-LD Core @context

```
"ngsi-ld": "https://uri.etsi.org/ngsi-ld/",
"geojson": "https://purl.org/geojson/vocab#",
"id": "@id",
"type": "@type",

"Date": "ngsi-ld:Date",
"DateTime": "ngsi-ld:DateTime",
"LineString": "geojson:LineString",

"Point": "geojson:Point",
"Polygon": "geojson:Polygon",
 "GeoProperty": "ngsi-ld:GeoProperty",
"Property": "ngsi-ld:Property",
"Relationship": "ngsi-ld:Relationship",

"ContextSourceNotification":"ngsi-ld:ContextSourceNotification",
"ContextSourceRegistration":"ngsi-ld:ContextSourceRegistration",
"Notification": "ngsi-ld:Notification",
"Subscription": "ngsi-ld:Subscription",
```

… etc

```
"coordinates": {
   "@container": "@list",
   "@id": "geojson:coordinates"
 },
"location": "ngsi-ld:location",
"observedAt": {
    "@id": "ngsi-ld:observedAt",
    "@type": "DateTime"
 },
"unitCode": "ngsi-ld:unitCode",
"value": "ngsi-ld:hasValue",
```

… etc

```
"@vocab": "https://uri.etsi.org/ngsi-ld/default-context/"
```

- Common NGSI-LD terms in the core `@context` for metadata - **`unitCode`**, **`observedAt`**
- Common NGSI-LD terms for geoproperties - **`Point`**, **`LineString`**, **`location`**, **`coordinates`**, etc.

Device measures should always reuse the **predefined** terms

Implementation Specific @context

```
"fiware": "https://uri.fiware.org/ns/data-models#",
"schema": "https://schema.org/",
"example": "https://example.com/datamodels.html/",
"Building": "fiware:Building",
"Device": "fiware:Device",
"FillingLevelSensor": "example:FillingLevelSensor",
"SoilSensor": "example:SoilSensor",
"TemperatureSensor": "example:TemperatureSensor",
"Tractor": "example:Tractor",
"Water": "example:Water",
```

… etc

```
"accuracy": "fiware:accuracy",
"batteryLevel": "fiware:batteryLevel",
"category": "fiware:category",
"controlledAsset": "fiware:controlledAsset",
"controlledProperty": "fiware:controlledProperty",
"deviceState": "fiware:deviceState",
"ipAddress": "fiware:ipAddress",
"macAddress": "fiware:macAddress",
"mcc": "fiware:mcc",
"osVersion": "fiware:osVersion",
```

- Reuse common data models and ontologies
- Add use-case specific mappings where necessary
- Remember to map all entities types, attributes and metadata attributes

Undefined terms will fallback to the default context
`https://uri.etsi.org/ngsi-ld/default-context`

```
"actuator": "https://w3id.org/saref#actuator",
"filling": "https://w3id.org/saref#fillingLevel",
"temperature": "https://w3id.org/saref#temperature",
"sensor": "https://w3id.org/saref#sensor",
"status": "https://saref.etsi.org/core/status",
"state": "https://saref.etsi.org/core/hasState",

"heartRate":
  "https://purl.bioontology.org/ontology/MESH/D006339",
```

… etc

```
"myCustomAttr": "example:mycustomAttr",
"secondCustomAttr": "example:2ndCustomAttr"
```

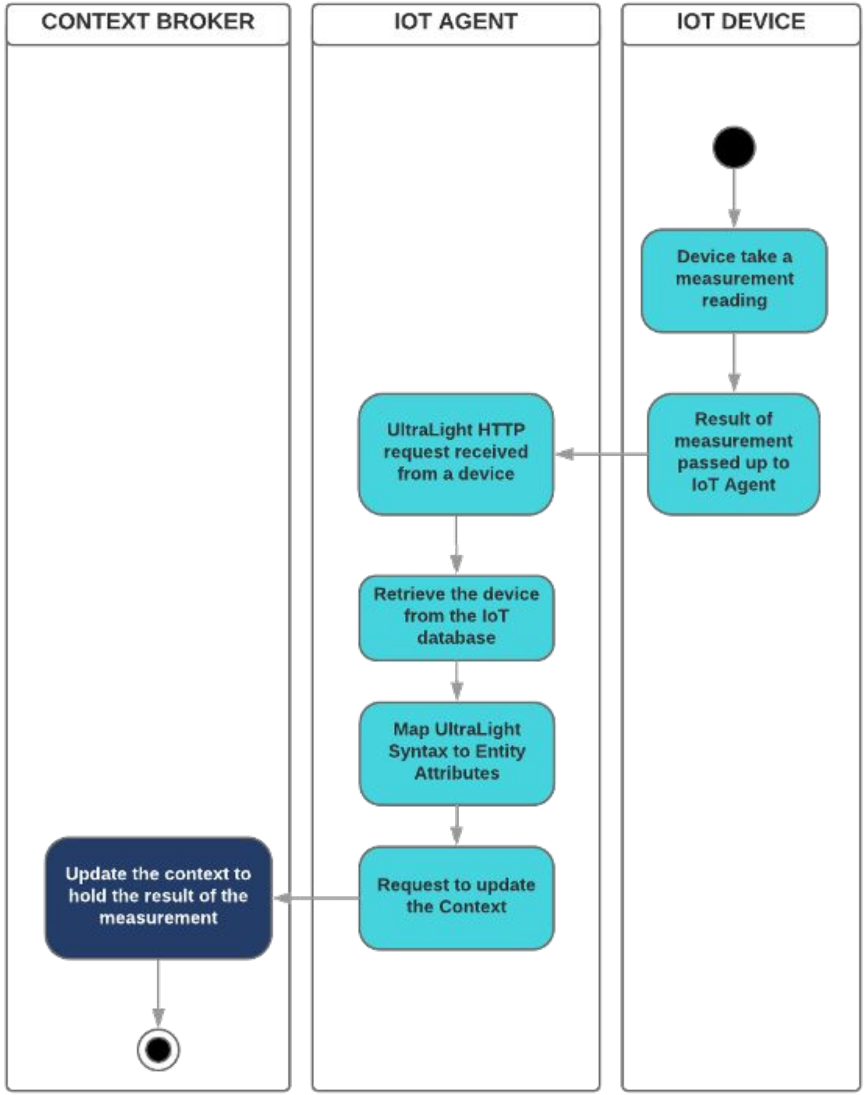
NGSI-LD Measures

- The **IoT Device** is using a known payload syntax
  - Ultralight, JSON, SigFox, OPC-UA etc.

- The **IoT Device** sends a reading using the agreed protocol
  - HTTP, MQTT, AMPQ, LoRaWAN etc.

- The **IoT Agent** interprets the payload and transforms the measure into NGSI-LD

- The only interface to the **Context Broker** is a simple structured upsert of entities
  - potentially including linked entities


CONTEXT BROKER
IOT AGENT
IOT DEVICE
Device take a measurement reading
Result of measurement passed up to IoT Agent
UltraLight HTTP request received from a device
Retrieve the device from the IoT database
Map UltraLight Syntax to Entity Attributes
Request to update the Context
Update the context to hold the result of the measurement

Measure: *“Device X in Building Y has registered 25°C”*

NGSI-LD Context Broker receives upsert

```
curl -L -X POST
'http://localhost:1026/ngsi-ld/v1/entityOperations/upsert' \
-H 'Content-Type: application/ld+json' \
-d '[
    {
        "@context": "http://example.com/context.json-ld",
        "id": "urn:ngsi-ld:Device:thermometer1",
        "type": "Device"
        "temperature": {
            "type": "Property",
            "value": 25,
            “observedAt": "2015-08-05T07:35:01.468Z",
            "unitCode": "CEL",
            "accuracy":{
              "type": "Property", "value": 1
             }
         },
        "controlledAsset": {
            "type": "Relationship",
            "object": "urn:ngsi-ld:Building:building1"
        }
    }
]'
```

NGSI v2 Context Broker equivalent

```
curl -iX POST
'http://localhost:1026/v2/entities/
         urn:ngsi-ld:Device:thermometer1/attrs' \
-H 'Content-Type: application/json' \
-d '{
    "temperature": {
       "type": "Number",
       "value": "25",
       "metadata": {
           "TimeInstant":{
              "type": "DateTime",
              "value": "2015-08-05T07:35:01.468Z"
           },
           "unitCode":{
              "type": "String", "value": "CEL"
           },
           "accuracy":{
              "type": "Number", "value": 1
           }
      },
    "controlledAsset": {
      "type": "Relationship"
      "value": "urn:ngsi-ld:Building:building1"
    }
  }'
```

Provisioning an NGSI-LD Service Group

/iot/services endpoint defines common elements across groups of devices

- **entity_type**, **attributes** and **static_attributes** correspond to a data model found within the @context file
- **attributes** and **static_attributes** may have associated metadata.
- types should be defined as:
  - **Property**
  - **Relationship**
  - A native JSON type
  - A GeoJSON type

```
curl -s -o /dev/null -X POST \
  'http://iot-agent:4041/iot/services' \
  -H 'Content-Type: application/json' -H 'fiware-service: openiot' \
  -d '{
 "services": [
   {
     "apikey":      "321701236",
     "cbroker":     "http://orion:1026",
     "entity_type": "Device",
     "resource":    "/iot/d",
     "protocol":    "PDI-IoTA-UltraLight",
     "transport":   "HTTP",
     "timezone":    "Europe/Berlin",
     "attributes": [
       { "object_id": "t", "name":"temperature", "type": "Float",
         "metadata": {"unitCode": {"type": "Property","value": "CEL"}}
       }
      ],
      "static_attributes": [
        {"name": "description",
         "type":"Property", "value": "Thermometer"},
        {"name": "category", "type":"Property", "value": ["sensor"]},
        {"name": "controlledProperty",
         "type": "Property", "value": "temperature"},
        {"name": "supportedProtocol",
         "type": "Property", "value": ["ul20"]}
      ]
   }
 ]
}'
```

Provisioning NGSI-LD device

/iot/devices endpoint defines additional data for an individual device

- **attributes** and **static_attributes** can also be defined at the device level - the standard rules about types apply
- Use **link** on a **static_attribute** to update a linked Entity

```
curl -s -o /dev/null -X POST \
  'http://iot-agent:4041/iot/devices' \
  -H 'Content-Type: application/json' \
  -H 'fiware-service: openiot' \
  -H 'fiware-servicepath: /' \
  -d '{
 "devices": [
   {
     "device_id":   "txhme001xxe",
     "entity_name": "urn:ngsi-ld:Device:temperature001",
     "entity_type": "Device",
     "static_attributes": [
        {
          "name": "controlledAsset",
          "type": "Relationship",
          "value": "urn:ngsi-ld:Building:001",
          "link": {
             "attributes": ["temperature"],
             "name": "providedBy",
             "type": "Building"
          }
        }
     ]
  }
]
```

GPS Measure: *“GPS X has moved to location x,y”*

With location payloads such as:

- **As Ultralight String**
  ```
  gps|13.3501,52.5143
  ```
- **As Ultralight Multiple attributes**
  ```
  lng|13.3501|lat|52.5143
  ```
- **JSON as string value:**
  ```
  {"gps": "13.3501,52.5143"}
  ```
- **JSON as array value:**
  ```
  {"gps": [13.3501, 52.5143]}
  ```
- **JSON as GeoJSON:**
  ```
  {
      "gps": {
         "type": "Point",
         "coordinates": [13.3501, 52.5143]
      }
   }
  ```
- etc...

Context Broker receives an NGSI-LD upsert

```
curl -L -X POST
'http://localhost:1026/ngsi-ld/v1/entityOperations/upsert' \
-H 'Content-Type: application/ld+json' \
-d '[
  {
    "@context": "http://example.com/context.json-ld",
    "id": "urn:ngsi-ld:Device:gps1",
    "type": "Device"
    "location": {
      "type": "GeoProperty",
      "value": :{
       "type": "Point",
       "coordinates": [13.3501, 52.5143]
      },
      “observedAt": "2015-08-05T07:35:01.468Z"
    },
    "controlledAsset": {
      "type": "Relationship",
      "object": "urn:ngsi-ld:Tractor:tractor1"
    }
  }
]'
```

Provisioning GPS Devices

GPS Provisioning from a single input

- Use **`location`** as the **`name`** of a geolocation attribute
- Set **`type=GeoProperty`** or any GeoJSON type
- Map an attribute **`object_id`** to NGSI-LD attribute **`name`**

Aliasing Latitude and Longitude as separate inputs

- Use **`location`** as the **`name`** of a geolocation attribute
- Set **`type=GeoProperty`** or any GeoJSON type
- Use **`expression`** aliasing to map multiple inputs to a String
- Remember GeoJSON uses Lng/Lan format
- Will only fire if both latitude and longitude are present in the payload

IoT Agent Device Provisioning

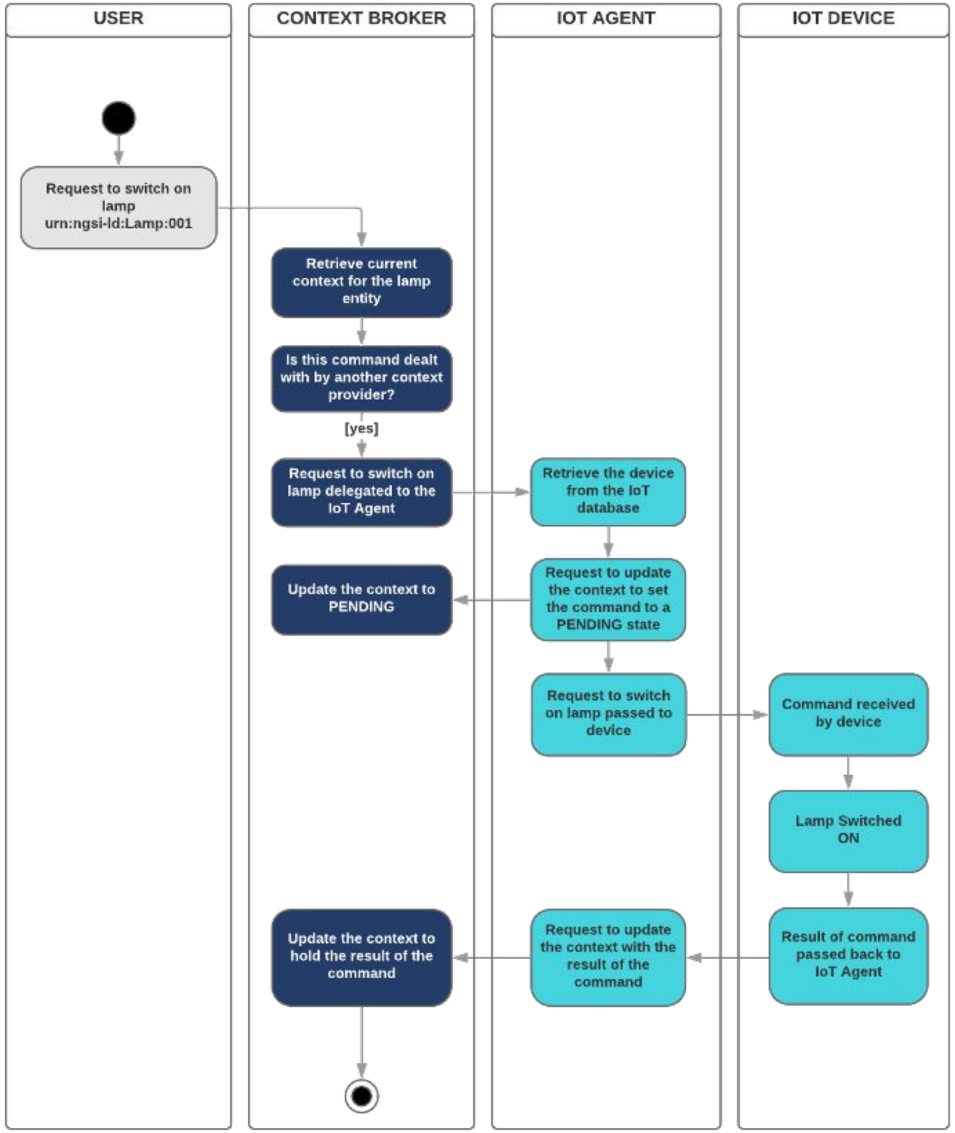
```
{
  "object_id": "gps",
  "name":"location",
  "type": "geo:point"
}
```

```
{
   "name": "location",
   "type": "geo:json",
   "expression": "${@lng}, ${@lat}"
}
```

All **GeoProperty** input values are automatically converted into GeoJSON in the NGSI-LD upsert

NGSI-LD Actuations

- NGSI-LD actuation code is currently based on the existing NGSI-v2 IoT Agent paradigm.
- Uses **registrations** and **request forwarding**
- Some details of the ETSI specification around the final actuation interface still being discussed:
  - Federation?
  - Subscription based?
  - Full Actuation Interface?
- The listening mechanism is internal to the IoT Agent library and will be updated once the proposed interface is finalized.



USER

CONTEXT BROKER

IOT AGENT

IOT DEVICE

Request to switch on lamp urn:ngsi-ld:Lamp:001

Retrieve current context for the lamp entity

Is this command dealt with by another context provider?

[yes]

Request to switch on lamp delegated to the IoT Agent

Retrieve the device from the IoT database

Request to update the context to set the command to a PENDING state

Update the context to PENDING

Request to switch on lamp passed to device

Command received by device

Lamp Switched ON

Result of command passed back to IoT Agent

Request to update the context with the result of the command

Update the context to hold the result of the command

Command provisioning actuation **registration** (with Multi-tenancy): *“I am responsible for Attribute X”*

IoT Agent Device Provisioning

```
curl -L -X POST 'http://localhost:4041/iot/devices' \
    -H 'fiware-service: openiot' \
    -H 'Content-Type: application/json' \
--data-raw '{
  "devices": [
    {
      "device_id": "water001",
      "protocol": "PDI-IoTA-UltraLight",
      "transport": "HTTP",
      "endpoint": "http://device:3001/iot/water001",
      "entity_name": "urn:ngsi-ld:Device:water001",
      "entity_type": "Device",
      "commands": [
        {
          "name": "on",
          "type": "command"
        },
        {
          "name": "off",
          "type": "command"
        }
       ]
    }
  ]
}'
```

Context Broker receives a Registration

```
curl -L -X POST 'http://localhost:1026/ngsi-ld/v1/csourceRegistrations' \
  -H 'NGSILD-Tenant: openiot' \
  -H 'Content-Type: application/ld+json' \
  -d '{
      "@context": "http://context.json-ld",
      "endpoint": "http://iotagent.com",
      "information": [
          {
              "entities": [
                  {
                      "id": "urn:ngsi-ld:Device:water001",
                      "type": "Device"
                  }
              ],
              "properties": [
                  "on",
                  "off"
              ]
          }
      ],
      "type": "ContextSourceRegistration"
  }
  '
```

Actuation **Request Forwarding** (with Multi-tenancy)

Context Broker receives an Actuation

```
curl -L -X PATCH 'http://localhost:1026/ngsi-ld/v1/entities/urn:ngsi-ld:Device:water001/attrs/on' \
     -H 'NGSILD-Tenant: openiot' -H 'Content-Type: application/json' \
     -H 'Link: <http://context-provider:3000/data-models/ngsi-context.jsonld>; rel="http://www.w3.org/ns/json-ld#context";
  type="application/ld+json"' \
--data-raw '{ "type": "Property", "value": " " }'
```

IoT Agent receives a forwarded Actuation

```
curl -L -X PATCH 'http://localhost:4041/ngsi-ld/v1/entities/urn:ngsi-ld:Device:water001/attrs/on' \
     -H 'NGSILD-Tenant: openiot' -H 'Content-Type: application/json' \
     -H 'Link: <http://context-provider:3000/data-models/ngsi-context.jsonld>; rel="http://www.w3.org/ns/json-ld#context";
  type="application/ld+json"' \
--data-raw '{ "type": "Property", "value": " "}'
```

Multitenancy uses `NGSILD-Tenant` header if found, or the `fiware-service` header for backwards compatibility. And uses `IOTA_FALLBACK_TENANT` as a final backstop.

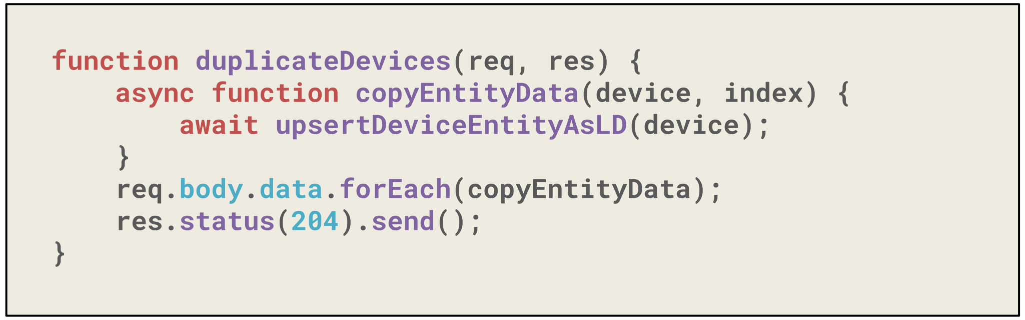
Combining NGSI-v2 and LD

- Mapping NGSI-v2 to NGSI-LD is simple - just re-use mapping code from within the IoT Agent library

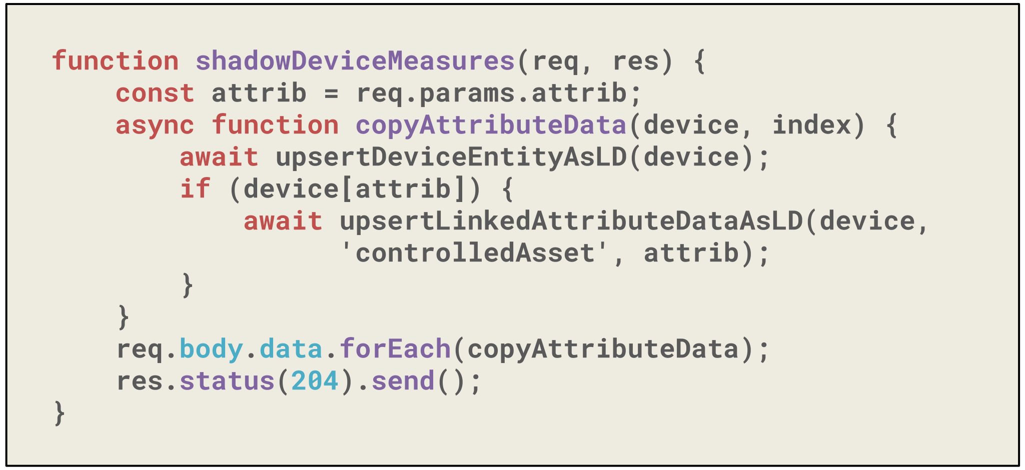
- Use a one-shot **subscription** to duplicate existing entities

- Ongoing **subscription** for shadowing device measures and creating linked data entities with `providedBy` and `observedAt` metadata attributes

- Sample code:
  https://github.com/FIWARE/tutorials.Step-by-Step/blob/master/context-provider/controllers/ngsi-ld/device-convert.js



```
function duplicateDevices(req, res) {
    async function copyEntityData(device, index) {
        await upsertDeviceEntityAsLD(device);
    }
    req.body.data.forEach(copyEntityData);
    res.status(204).send();
}
```



```
function shadowDeviceMeasures(req, res) {
    const attrib = req.params.attrib;
    async function copyAttributeData(device, index) {
        await upsertDeviceEntityAsLD(device);
        if (device[attrib]) {
            await upsertLinkedAttributeDataAsLD(device,
                  'controlledAsset', attrib);
        }
    }
    req.body.data.forEach(copyAttributeData);
    res.status(204).send();
}
```

Summary

- The IoT Agent Library now supports basic **NGSI-LD** operation
  - Already ported to most IoT Agents. Just upgrade to the latest version of the library
  - Some internal actuation mechanisms are still subject to change.

- IoT Device provisioning has barely changed from **NGSI-v2**
  - **`Property`**, **`GeoProperty`** and **`Relationship`** are reserved keywords
  - Use native JSON types and GeoJSON types whilst provisioning
  - Use metadata and avoid meaningless **`type`** attributes
  - More info: https://iotagent-node-lib.readthedocs.io/

- **JSON-LD `@context`** makes your data interoperable.
  - Ensure your JSON-LD **`@context`** is maintained and **publicly available**
  - JSON-LD specification: https://json-ld.org/
  - More info: https://github.com/FIWARE/tutorials.Understanding-At-Context

- Fallback to using subscriptions and mapping when combining **NGSI-v2** Devices with an **NGSI-LD** Context Broker

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