OGC SensorThings API

and

FROST Server®

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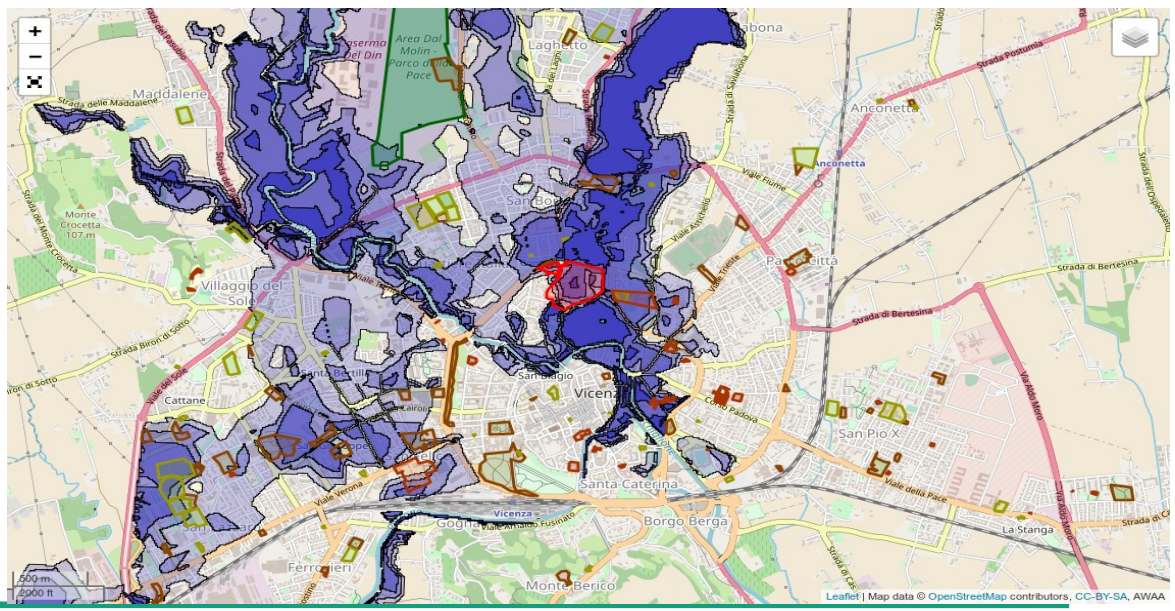
Open Geospatial Consortium

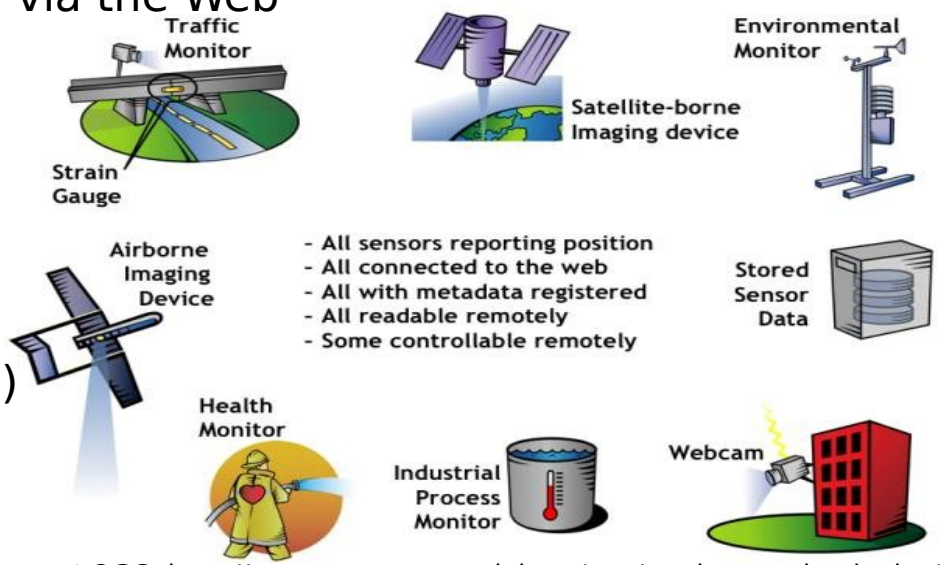
http://www.opengeospatial.org

- International consortium
  - over 522 companies, government agencies and universities
- “Geo-enable” mainstream IT
- Develop publicly available standards
  - Web Map Service
  - CityGML
  - WaterML
  - Earth Observations



OGC & IoT?

- IoT deals with Sensors and Actuators
- Sensors and Actuators have Location
- OGC Sensor Web Enablement (SWE)
  - Enable developers to make *all types* of sensors and sensor data repositories discoverable, accessible and useable via the Web
  - Since 1990 by NASA
  - Since 2001 in OGC
  - SensorML
    Sensor Observation Service (SOS)
    Sensor Planning Service (SPS)
    Observations & Measurements (O&M)
  - Sensor Data & Metadata



©OGC: http://www.opengeospatial.org/ogc/markets-technologies/swe

From SWE to SensorThings

- “Old” SWE Standards
  - XML Encoded
  - SOAP bindings
  - Complex in use
    - No easy browsing
    - No pagination
    - No pub/sub

Time for an update → SensorThings API

OGC SensorThings API

https://www.opengeospatial.org/standards/sensorthings
https://github.com/opengeospatial/sensorthings

- A standard for exchanging sensor data and metadata
  - Historic data & current data
  - JSON Encoded
  - RESTful
  - Adapting OASIS OData URL patterns and query options
  - Supporting MQTT pub/sub
- Easy to use & understand
  - Discoverable with only a web browser

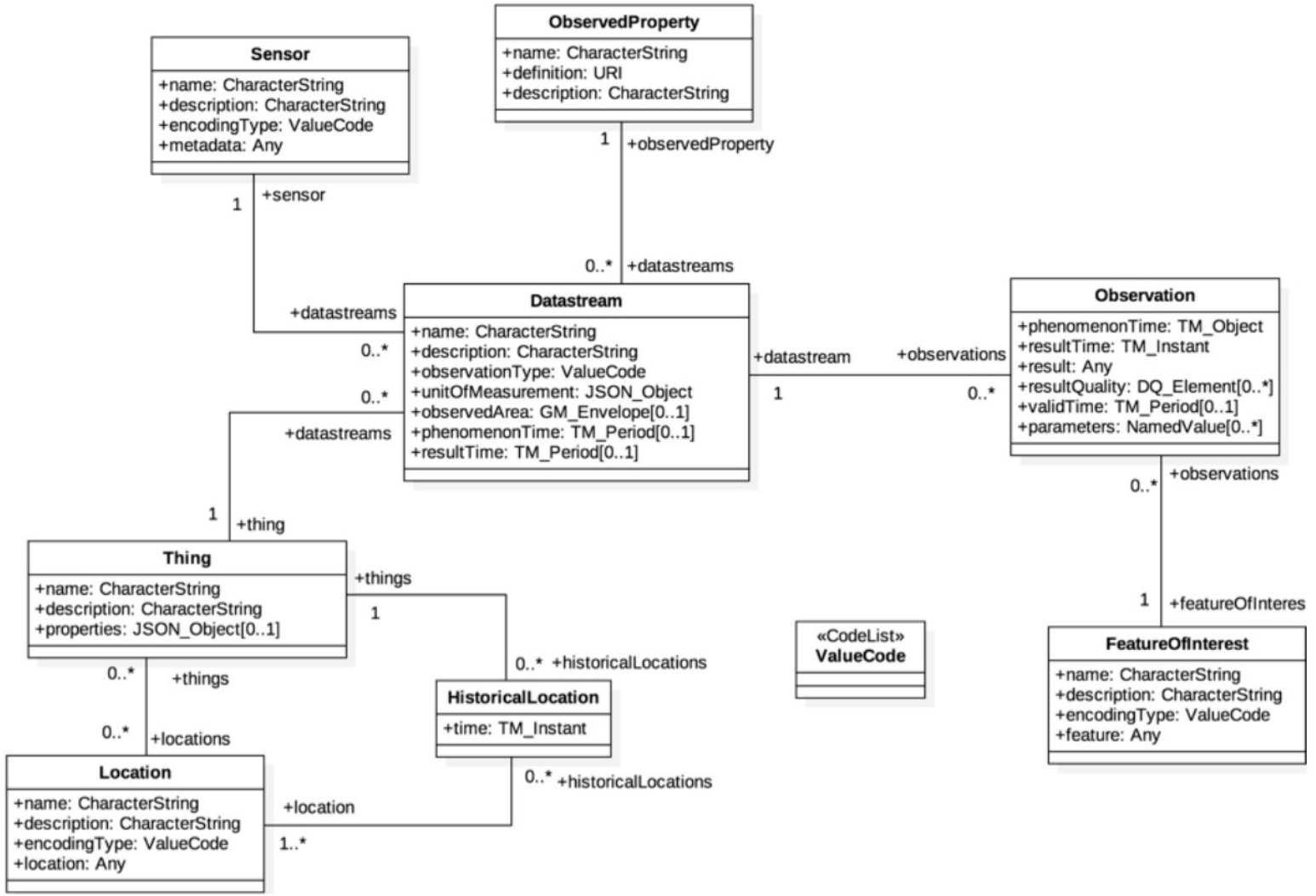
OGC SensorThings API

- Divided into multiple Parts
  - Part I: Sensing (published 07/2016)
  - Part II: Tasking Core (published 01/2019)
  - Part III: Rule Engine
- Part I: Sensing
  - Mandatory: Basic read access
  - Extensions
    - Filtering
    - Create/Update/Delete
    - Batch Processing
    - MultiDatastreams
    - Data Arrays
    - MQTT: Create Observations
    - MQTT: Receive updates
  - Conformance Test Suite

How does it work?

- Data Model
  - What kind of entities exist?
  - How are they connected?
- API
  - Basic read access
  - Filtering
  - Create/Update/Delete

Data Model



HTTP API: Basic operations

- Base URL: `http://server.org/FROST-Server/v1.0`
- Read: HTTP GET
  - `v1.0` → Get collection index
  - `v1.0/Collection` → Get all entities in a collection
  - `v1.0/Collection(id)` → Get one entity from a collection
- Create: HTTP POST
  - `v1.0/Collection` → Create a new entity
- Update: HTTP PATCH
  - `v1.0/Collection(id)` → Update an entity
- Update: HTTP PUT
  - `v1.0/Collection(id)` → Replace an entity
- Delete: HTTP DELETE
  - `v1.0/Collection(id)` → Remove an entity

HTTP API: Get a Collection

HTTP GET `v1.0/Things`

- Response

```
{
  "value" : [
    {
      "name" : "My camping lantern",
      "description" : "camping lantern",
      "properties" : {
        "property1" : "it's waterproof",
        "property2" : "it glows in the dark"
      },
      "Locations@iot.navigationLink" : "Things(1)/Locations",
      "HistoricalLocations@iot.navigationLink": "Things(1)/HistoricalLocations",
      "Datastreams@iot.navigationLink" : "Things(1)/Datastreams",
      "@iot.id" : 1,
      "@iot.selfLink" : "/FROST-Server/v1.0/Things(1)"
    },
    {
      a second thing…
    }, { … }, { … }, { … }
  ]
}
```

HTTP API: Get an Entity

HTTP GET `v1.0/Things(1)`

- Response


```
{
  "name" : "My camping lantern",
  "description" : "camping lantern",
  "properties" : {
    "property1" : "it's waterproof",
    "property2" : "it glows in the dark"
  },
  "Locations@iot.navigationLink" : "Things(1)/Locations",
  "HistoricalLocations@iot.navigationLink" : "Things(1)/HistoricalLocations",
  "Datastreams@iot.navigationLink" : "Things(1)/Datastreams",
  "@iot.id" : 1,
  "@iot.selfLink" : "/FROST-Server/v1.0/Things(1)"
}
```

HTTP API: Get related Entities

Get all Datastreams of a specific Thing

- HTTP GET `v1.0/Things(1)/Datastreams`
- Response

```
{
  "value" : [
    {…},
    {…},
    {…}
  ]
}
```

HTTP API: Pagination

Get only 4 Observations and the total count of Observations

- HTTP GET `v1.0/Observations?$top=4&$count=true`
- Response

```
{
  "@iot.count" : 16,
  "@iot.nextLink" : "/FROST-Server/v1.0/Observations?$top=4&$skip=4",
  "value" : [
    { … },
    { … },
    { … },
    { … }
  ]
}
```

HTTP API: Sorting

Get all Observations sorted by phenomenonTime, newest first

- HTTP GET `v1.0/Observations?$orderby=phenomenonTime desc`

- Functions work for Ordering
  HTTP GET `v1.0/Datastreams?$orderby=length(name) desc`

HTTP API: Filtering

Get only Observations with result (value) > 5

- HTTP GET `v1.0/Observations?$filter=result gt 5`
- Response

```
{
  "@iot.nextLink" : "/FROST-Server/v1.0/Observations?$filter=result gt 5&$top=4&$skip=4",
  "value" : [
    {
      "phenomenonTime" : "2016-06-22T13:21:31.144Z",
      "resultTime" : null,
      "result" : 10,
      "@iot.id" : 34,
      "@iot.selfLink" : "/FROST-Server/v1.0/Observations(34)"
    }, {
      …
    }, {
      …
    }, {
      …
    }
  ]
}
```

HTTP API: Filtering Functions 1

- Comparison Operators
  - gt
  - ge
  - eq
  - le
  - lt
  - ne
- Logical Operators
  - and
  - or
  - not
- Mathematical Operators
  - add
  - sub
  - mul
  - div
  - mod
- String Functions
  - substringof(p0, p1)
  - endswith(p0, p1)
  - startswith(p0, p1)
  - substring(p0, p1)
  - indexof(p0, p1)
  - length(p0)
  - tolower(p0)
  - toupper(p0)
  - trim(p0)
  - concat(p0, p1)
- Mathematical Functions
  - round(n1)
  - floor(n1)
  - ceiling(n1)

HTTP API: Filtering Functions 2

- Geospatial Functions
  - `geo.intersects(g1, g2)`
  - `geo.length(l1)`
  - `geo.distance(g1, g2)`
  - `st_equals(g1, g2)`
  - `st_disjoint(g1, g2)`
  - `st_touches(g1, g2)`
  - `st_within(g1, g2)`
  - `st_overlaps(g1, g2)`
  - `st_crosses(g1, g2)`
  - `st_intersects(g1, g2)`
  - `st_contains(g1, g2)`
  - `st_relate(g1, g2)`
- Date and Time Functions
  - `now()`
  - `mindatetime()`
  - `maxdatetime()`
  - `date(t1)`
  - `time(t1)`
  - `year(t1)`
  - `month(t1)`
  - `day(t1)`
  - `hour(t1)`
  - `minute(t1)`
  - `second(t1)`
  - `fractionalseconds(t1)`
  - `totaloffsetminutes(t1)`

HTTP API: Filtering examples

- All observations with an even result
  - `v1.0/Observations?$filter=result mod 2 eq 0`
- Observations of the last hour
  - `v1.0/Observations?$filter=phenomenonTime gt now() sub duration'PT1H'`
  - https://en.wikipedia.org/wiki/ISO_8601#Durations
- Datastreams that measure temperature
  - `v1.0/Datastreams?$filter=ObservedProperty/name eq 'temperature'`

HTTP API: $select

Get only description und id for all Things

- HTTP GET `v1.0/Things?$select=@iot.id,description`
- Response

```
{
  "value" : [
    {
      "description" : "camping lantern",
      "@iot.id" : 1
    },
    {
      "description" : "camping stove",
      "@iot.id" : 2
    }
  ]
}
```

HTTP API: $expand

Get the Thing with id=17 and its Datastreams

- HTTP GET `v1.0/Things(17)?$expand=Datastreams`
- Response

```
{
  "name" : "My camping lantern",
  "description" : "camping lantern",
  "Datastreams" : [
    { … },
    { … },
    { … }
  ],
  "@iot.id" : 17
}
```

HTTP API: $expand(…)

Get only description, id and Datastreams for Thing 17 and for the Datastreams only id and description:

- HTTP GET `v1.0/Things(17)?$select=@iot.id,description&$expand=Datastreams($select=@iot.id,description)`
- Response

```
{
  "description" : "camping lantern",
  "@iot.id" : 17,
  "Datastreams" : [
    {
      "description" : "Temperature measurement",
      "@iot.id" : 19
    },
    {
      "description" : "Humidity measurement",
      "@iot.id" : 21
    }
  ]
}
```

Questions?

FROST Server®

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FROST® Server

https://github.com/FraunhoferIOSB/FROST-Server (Code)
http://akme-a3.iosb.fraunhofer.de/FROST-Server/v1.0 (Demo)

- **FR**aunhofer **O**pen Source **S**ensor**T**hings API Server
  - LGPL 3.0 license
- First implementation to include all extension
  - Based on JavaEE / PostgreSQL / PostGIS
- Official OGC reference implementation
- High scalability
  - Single-board computers (e.g. RaspberryPi)
  - Local server (clusters)
  - Cloud/Data Center

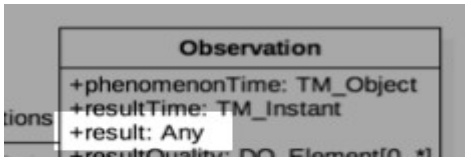
Agenda

- History
- Features
- Deployment
- FROST Landscape

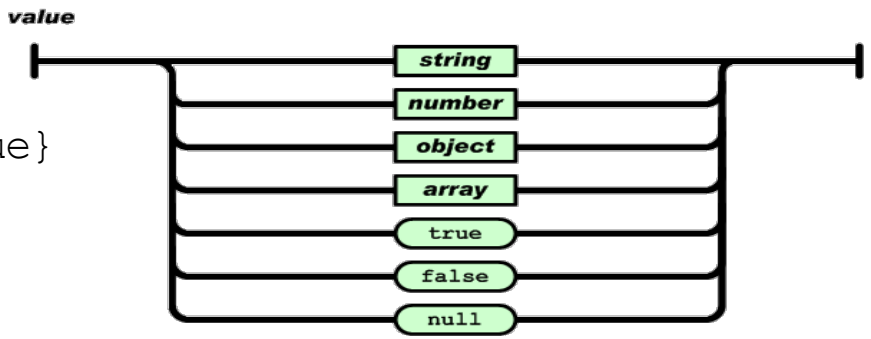
History

- 2016-02: Start of development
  - Goal: A full implementation of the STA
- 2016-07: Open-Source (LGPL) on GitHub
- 2016-11: v1.0 – CRUD, DataArray, MQTT
- 2016-11: MultiDatastream
- 2017-01: JSON filtering
- 2017-09: Docker support
- 2018-01: StringID & UUID Backends
- 2018-02: Batch Processing
  - Goal reached!
- 2018-04: Horizontal scalability
- 2018-04: Client-specified IDs
- 2018-08: HELM chart
- 2019-07: Tasking

Data Type Handling



- `Observation/result` has type `Any`
- Any? Anything that is valid in JSON
  - Number: `1.23e-3`
  - String: `"cloudy"`
  - Object: `{"temp": 1.2, "clouds": true}`
  - Array: `[1.2, 1.3, 0.9]`
  - Boolean: `true / false`
  - No-Value: `null`



FROST Server

- Truly type-conserving
- Type-specific ordering
- Type-safe filtering

Properties for all Entity Types STA v1.1

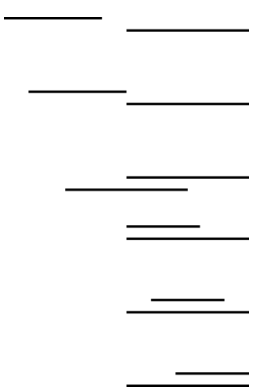
- In STA v1.0 for Things and Observations
  - `Thing/properties`
  - `Observation/parameters`
- Great for storing metadata related to external systems
- Properties for other entity types
  - `Datastream/properties`
  - `MultiDatastream/properties`
  - `FeatureOfInterest/properties`
  - `Location/properties`
  - `ObservedProperty/properties`
  - `Sensor/properties`

Filtering on sub-properties of JSON Objects

- Type-safe filtering
  - `v1.0/Things?`
    `$filter=properties/type eq 'room'`
  - `v1.0/Things?`
    `$filter=Locations/properties/floor eq 2`
  - `v1.0/Things?`
    `$filter=properties/enabled`
- Array access
  - `v1.0/Things?`
    `$filter=properties/thresholds[2] ge 5`
  - `v1.0/Things?`
    `$filter=properties/sizes[2][0]/length gt 1.1e-6`

Filtering for time intervals

- <, <=, == , >=, > are not enough when comparing time intervals
- Allen's Interval Algebra
  - before / after
  - meets
  - overlaps
  - starts
  - during
  - finishes



- Example

```
v1.0/MultiDatastreams(1)/Observations?
    $filter=overlaps(phenomenonTime,2018-01-01T00:00:00Z/P1D)
```

Filtering Delete

- STA v1.0 only allows delete on single entities
- DELETE on Collections with $filter support
  - `DELETE v1.0/Observations?`
    `$filter=phenomenonTime gt now() sub duration'P1M'`
  - `DELETE v1.0/Datastream(1)/Observations?`
    `$filter=phenomenonTime gt now() sub duration'P1D' mul`
    `Datastreams/Sensor/properties/keepDays`

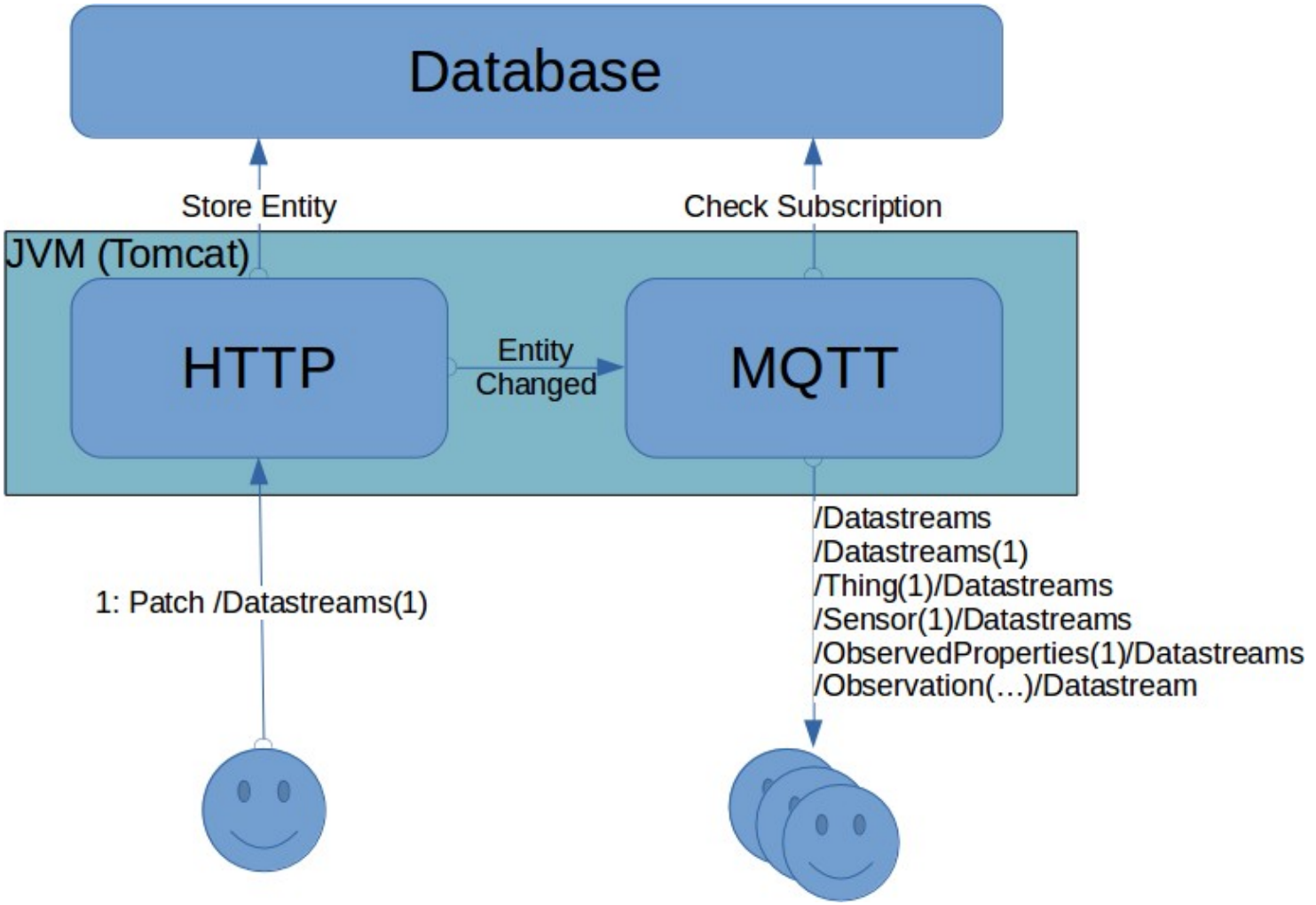
ID Handling

- Supported ID types in FROST-Server
  - Long (default) `{"@iot.id": 12345}`
  - UUID `{"@iot.id": "123e4567-e89b-12d3-a456-426655440000"}`
  - String `{"@iot.id": "http://example.org/ontology/superThing"}`
- ID generation methods
  - Server defined (default)
  - User defined
  - Mixed

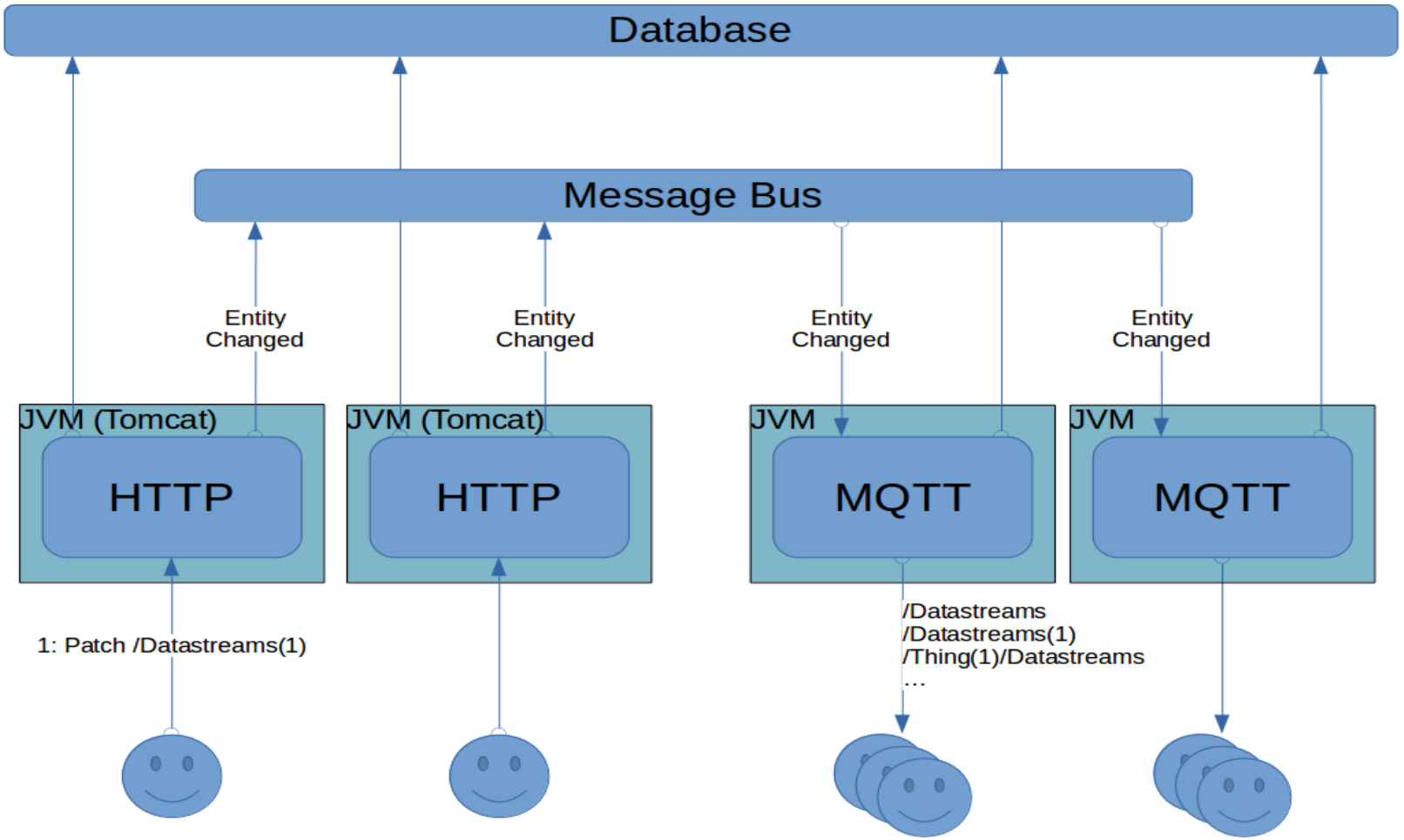
Deployment

- Two options
  - All-In-One
  - Separated HTTP and MQTT
- Deploy as
  - Docker
    - Docker images
      https://hub.docker.com/u/fraunhoferiosb/
    - Docker-compose examples
      https://github.com/FraunhoferIOSB/FROST-Server
    - Helm chart (for deployment on Kubernetes)
      https://github.com/FraunhoferIOSB/helm-charts
  - Tomcat
  - Spring Boot Application (via Kinota™ Server)
    https://github.com/kinota/kinota-server

Deployment: All-In-One



Deployment: Separated HTTP AND MQTT



Deployment: Docker

- Install docker & docker-compose
- Download docker-compose file
  - All-In-One
    https://raw.githubusercontent.com/FraunhoferIOSB/FROST-Server/master/docker-compose.yaml
  - Separated HTTP and MQTT
    https://raw.githubusercontent.com/FraunhoferIOSB/FROST-Server/master/docker-compose-separated.yaml
- Run docker-compose
  - All-In-One
    `> docker-compose up`
  - Separated HTTP and MQTT
    `> docker-compose -f docker-compose-seperated.yaml up`
- Open browser on `http://localhost:8080/FROST-Server/v1.0`

FROST Landscape

- Officially released https://github.com/FraunhoferIOSB/…
  - FROST-Server
  - FROST-Client
  - FROST-Manager
  - helm-charts
- Experimental Tools https://github.com/hylkevds/…
  - SensorThings-Dashboard
  - SensorThingsProcessor
  - SensorThingsImporter
  - SensorThingsCopier

Questions?

- OGC SensorThings API
  https://www.opengeospatial.org/standards/sensorthings
  https://github.com/opengeospatial/sensorthings
- FROST® Server
  https://github.com/FraunhoferIOSB/FROST-Server
- michael.jacoby@iosb.fraunhofer.de

Install FROST Server in only 3 simple steps NOW!

- > wget https://github.com/FraunhoferIOSB/FROST-Server/blob/master/docker-compose.yaml
- > docker-compose up
- open http://localhost:8080/FROST-Server/v1.0