Fraunhofer IOSB FROST Fraunhofer Opensource SensorThings 21.07.2023 Hylke van der Schaaf



- 2015: The (H2020) OpenIoT Project software... didn't work as hoped
- For a follow-up project we needed something that did work
  - Right around the time STA v1.0 was being finalised
  - There was no OpenSource server implementation yet
  - $\rightarrow$  We started work on a SensorThings Server implementation





- Fraunhofer IOSB
  - Research Institute
  - Financed through Projects
  - Renowned as domain experts
  - Not in the business of selling software...

- Open Source (LGPL)
  - Using FROST? → OK
  - FROST as library in a closed-source product?
    - → OK
  - Changing FROST?
    - $\rightarrow$  Release changes!



### **History** Seven years and counting...

- 2016-02: Start of development
  - Goal: A full implementation of the STA
- 2016-07: published 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: FROST has a name! Batch Processing
  - Goal reached!

- 2018-04: Horizontal scalability
- 2018-04: Client-specified IDs
- 2018-08: HELM chart
- 2019-01: Authentication
- 2019-07: Actuation
- 2020-02: CSV result format
- 2020-08: GeoJSON result format
- 2021-03: Deep & Distinct select
- 2022-05: Version 2.0
  - Data Model as Plugin
  - OData Support
  - Direct Data Streaming
- 2023-08: Fine-Grained Authorisation





- 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

 Observation

 +phenomenonTime: TM\_Object

 +resultTime: TM\_Instant

 +result: Any

 +resultQuality: DQ\_Element[0..\*]

 +validTime: TM\_Period[0..1]

 +parameters: NamedValue[0..\*]

### FROST:



- Truly type-conserving
- Type-specific ordering
- Type-safe filtering
- Precision-conserving
  - 2.00 stays 2.00



#### 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

#### Both configurable per EntityType

### Complex Filtering Searching...

#### Calculating with times and intervals

Observations?

\$filter=phenomenonTime gt now() sub duration'PT1H'

#### Compare observation result to a property of its Datastream

v1.0/Observations?

\$filter=result gt Datastream/properties/threshold

Fetch Observations for the last *n* days where *n* is specified in the Datastream

v1.0/Observations?

\$filter=phenomenonTime gt now() sub duration'PT1D' mul

Datastream/properties/fetchDays





#### Specialised Things



#### Flexible Data Models Make it fit your use case







#### Tomcat

### Docker

- Docker images https://hub.docker.com/r/fraunhoferiosb/frost-server https://hub.docker.com/r/fraunhoferiosb/frost-server-http https://hub.docker.com/r/fraunhoferiosb/frost-server-mqtt
- Docker-compose examples https://github.com/FraunhoferIOSB/FROST-Server
- HELM charts (for deployment on Kubernetes) https://github.com/FraunhoferIOSB/helm-charts





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



### Scalability For when your data grows





FROST History and Features

#### Performance A few numbers

#### Hamburg

- High volume:~2000 5000 per second
- Short retention ~1 Week
- Running on an auto-scaling Kubernetes cluster in Azure
- Air Quality Demo
  - Low volume: 12000 per hour
  - Long retention → ~700M Observations
  - Running on one node in our test Kubernetes cluster (On a SSD disk)



# Air Quality Outdoor, but indoor also works

Hull ambur województwo heffield Bremerhav 38 36 + achodniopomorskie Grudzia Groningen Liverpool Bremen Gorzów Bydg 26 -Nottingham England -Wielkopolski Włocławek Lower Saxony Alkmaa Greater Birmingham Niedersachsen Poland [] ales Norwich Wolfsburg 72 Lubus Peterborou Płock letherlands Voivodeship Osnabrück Voivodesh Pots Hannover Saxony województwo Poland Den Haag 61 ederland województwo Worcester Cambrido Anhalt wielkopolskie **Bielefeld** Polska The Haque lubuskie AF Sachsen-Gloucester 9 Oxford Kalisz Anhalt Paderbori North Rhine-49 ondon Cottbus Łódź wansea twerper Germany Le 25 rdrheinntwerp Kassel Bath **Deutschland** Brugge Lower Silesian Bruges Calais Thurinaid Sieger 20 Southampton ochowa Sac 11 Liberec wojen 41 Exeter gium Köln Portsmouth België Liège Hesse Cologne Opole Monse Hessen Prague Belgique Katowi Northeast-49 Koble Praha Belgien Hauts 83 kfurt am Luxembourg 68 Central Ostrava France Nürnberg Main Moravia wojew Letzebuerg Česko Plzeň Nuremberg Guernsey Le Ha Střední Rouen 40 Southwest Mannheim Morava Southeast Žilina Norman Jihovýchod Reims Karlsruhe Jersey aarbrücken Normandie Gran 42 Bayern Slov 23 63 ské. Ba Fs Budějovice Württemberg Vienna Slovensk Augsburg Wien 23 Ulm slava Rennes Bretagne München Le Mans Centre Salzbur reiburg Austria Munich oire Valley im Breisgau Österreich Centreays de Angers Bourgogne Val de Loire Sw 22 land 27 Loire Szombathel 23 Styria 20 Jungary Franche-Besancor mark Comté agyarország Schweiz France 57 Suisse Carinthia Poitiers Kärnten Maribo Svizzera Trentino-Svizra Alto Adige/ Südtiro Pécs Slov 22 24 La Rochelle lermont-Zagreb Limoges Ferrand Varese Annec Lomba 12 100 km Auver Rhôr Trieste ova 50 mi Piemont Alpe: Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, EEA, http://luft.umweltbundesamt.a

#### AirQuality

- All European Countries
- Harvested from EEA CSV files
- ~700M Observations after 2018

https://api4inspire.k8s.ilt-dmz.iosb.fraunhofer.de/servlet/is/127/



# **Rivers in Baden-Württemberg**

Locations can also be lines or polygons

# ~20000 Rivers and streams



https://api4inspire.k8s.ilt-dmz.iosb.fraunhofer.de/servlet/is/107/



# Urban Data Plattform Hamburg

Our first large user





FROST History and Features

## STA plus A new Data Model Extension





#### Fine-Grained security A very fresh feature

- User A can only insert Observations in certain Datastreams
- User B can edit entities linked to a certain Project
- normal users can only read non-restricted data

#### Can a User

- Create Entities of EntityType-X (new Observations)
- Link new Entity-X to Entity-Y (new Observation in DS-1)
- Update properties of Entity-X (Patch/Put Observation-1)
- Change a link of Entity-X from Entity-Y1 to Entity-Y2 (Move Observation-1 from DS-1 to DS-2)
- Delete Entity-X



# A Fine Grained Security Prototype

Your use case is probably different!





FROST History and Features



- Partner in European projects
- On-Line & On-Site
  - Introduction to SensorThings API
  - Data Modelling your use case
  - Setting up FROST
- Technical Support
- Custom extensions



# Contact

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