Water management at basin and plot level :

Transform agricultural sector to allow the activity to be more competitive and sustainable, using the latest proposals based on IoT and FIWARE: Projects DEMETER and WATERMED

Greencities: Digitalising the Future of Water, 2020

UNIVERSIDAD DE MURCIA

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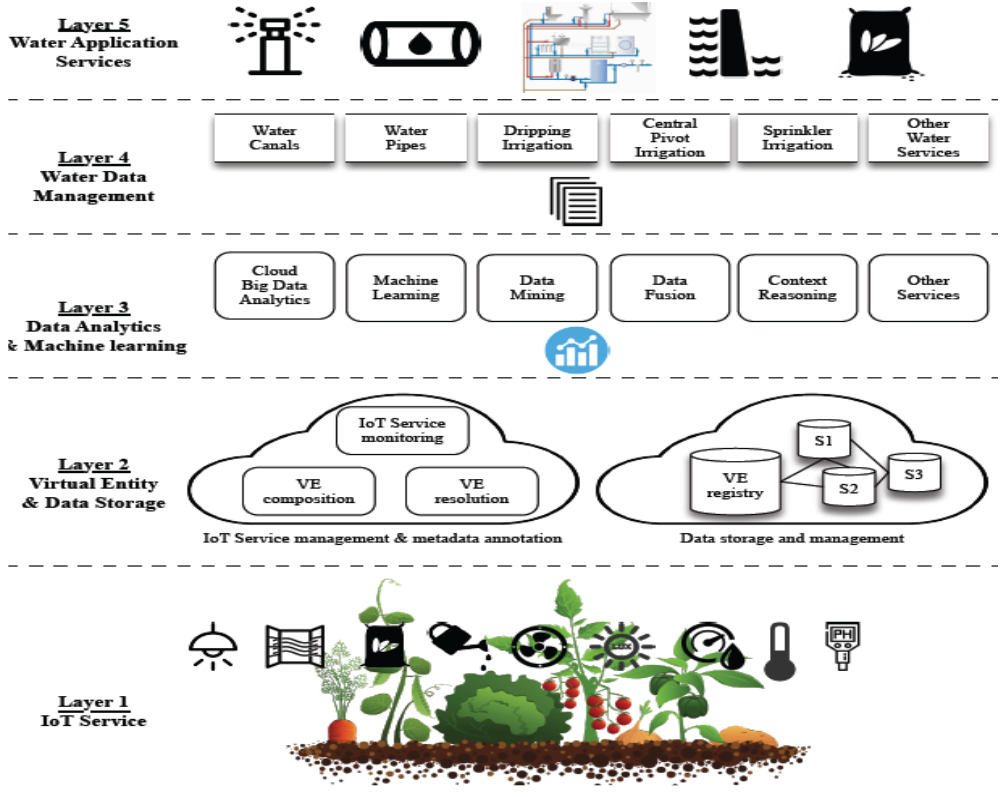
OdinS
Let us invent Smart Solutions

Motivation

- Several project ongoing on Digitalization of the Agrosector and water management (DEMETER, WATERMED, RESUAGUA…
- Difficulties up to now on the ICT part: no scalability, no use of standards, lack of integration,...: BUT now
  - Data connectivity protocols of IoT devices
  - Open interface to increase interoperability
  - Use of FIWARE components
  - Use of NGSI-LD

Integrated Architecture

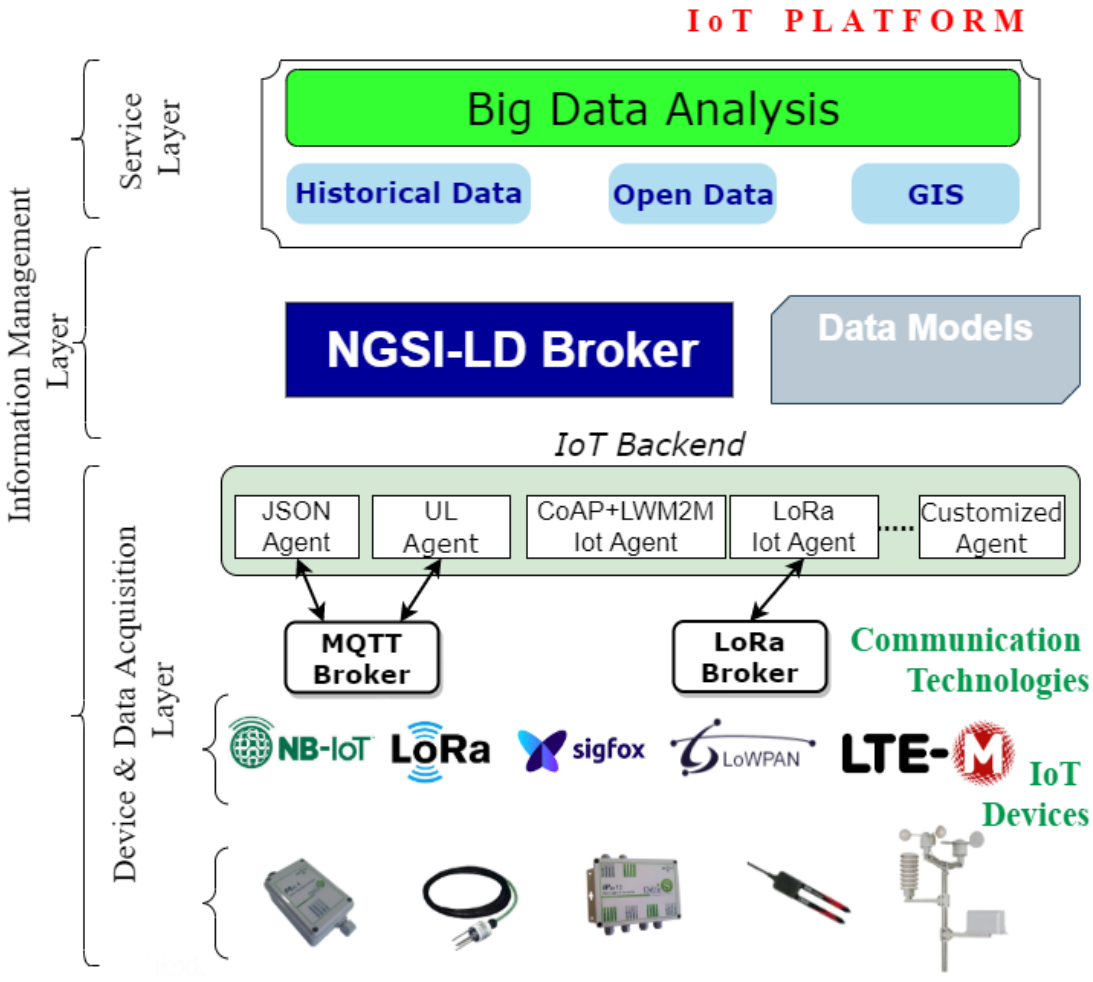
WATERMED 4.0: Efficient use and management of conventional and non-conventional water resources through smart technologies applied to improve the quality and safety of Mediterranean agriculture in semi-arid area



Use of an interoperable platform

It has a layered modular form ranging from the deployment of sensors and the monitoring of techniques for data extraction to the intelligent processing of data.

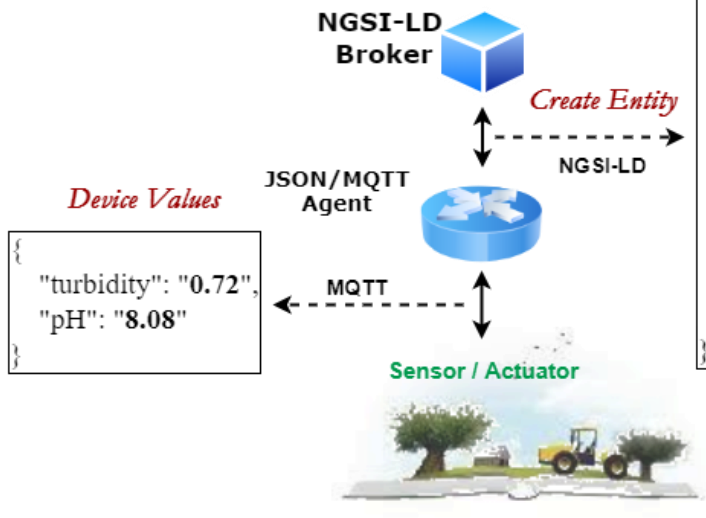
Each of these layers is based on open and standard initiatives, such as the one provided by the FIWARE Community



MIRAFLORES: Digital transformation of an irrigation community

Facilities	Quantity	Sensors
Header reservoir	1	reservoir level,filtered outlet pressure and reservoir inlet, ph, turbidity ammonium, nitrate, conductivity, phosphates, potassium, chlorides
Reservoirs	6	reservoir level
Wells	8	water temperature and flow, pressure and level deepwater
Filters	7	inlet and outlet pressure, cleaning flow, output flow
WWTP	1	network and solar pumping flow, network, solar pumping pressure wind speed, radiation
Wheather Station	2	temperature, humidity, wind, radiation, precipitation, vapor pressure deficit
Water Analysis	1	temperature, pH, suspended matter, BOD5, total phosphorus nitrites, phenols, hydrocarbons, ammonia, total ammonium ion residual chlorine, zinc and copper

One of the main problems to be solved is the integration of the different technological elements (SCADA, drawing software, independent sensors and third-party services) that provide information to the community, in a single control point.

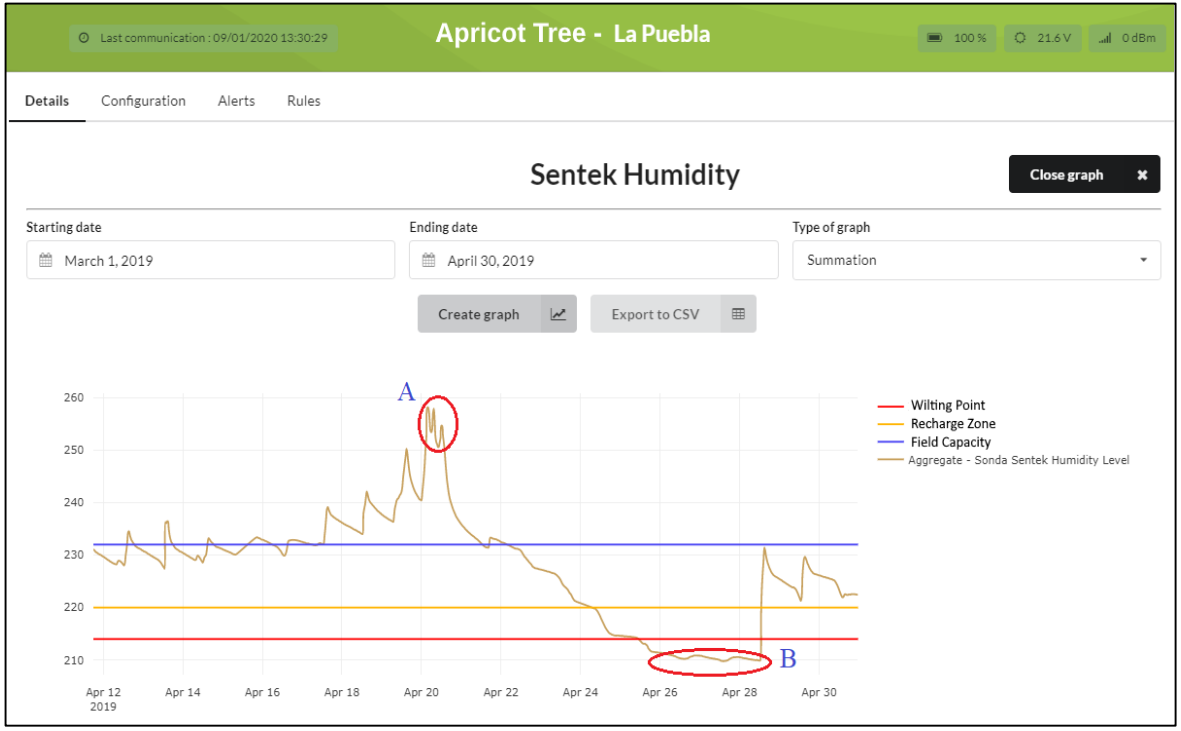



```
POST host:1026/v2/entities
Content-Type: application/json
.....
{
 "id": "April012019",
 "type": "WaterAnalysis"
 "turbidity":{
   "value": 0.72 },
 "ph":{
   "value": 8.08 },
 "location": {
   "type": "geo:json",
   "value":{
     "type": "Point",
     "coordinates":[38.440924,-1.334282]
   }
 }
}
```

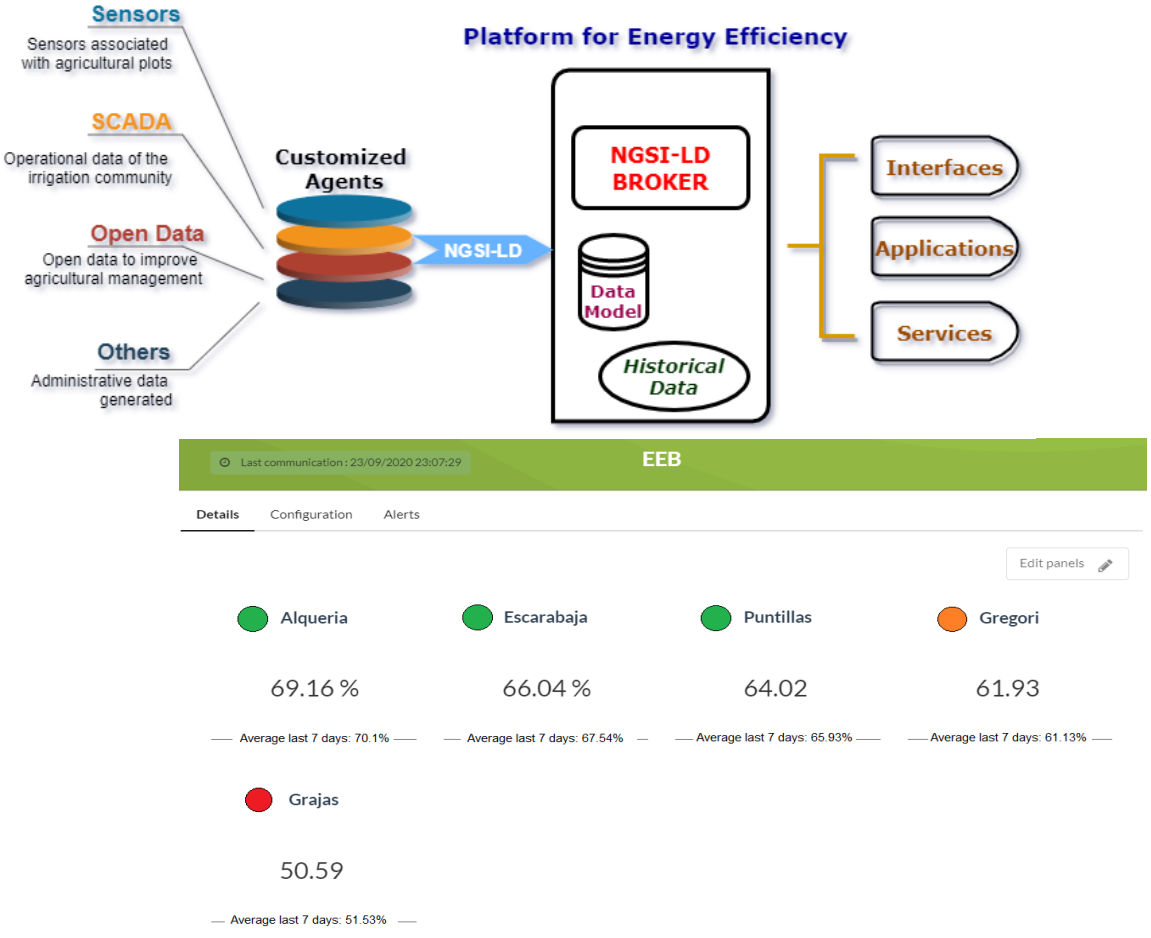
MIRAFLORES: Digital transformation of an irrigation community

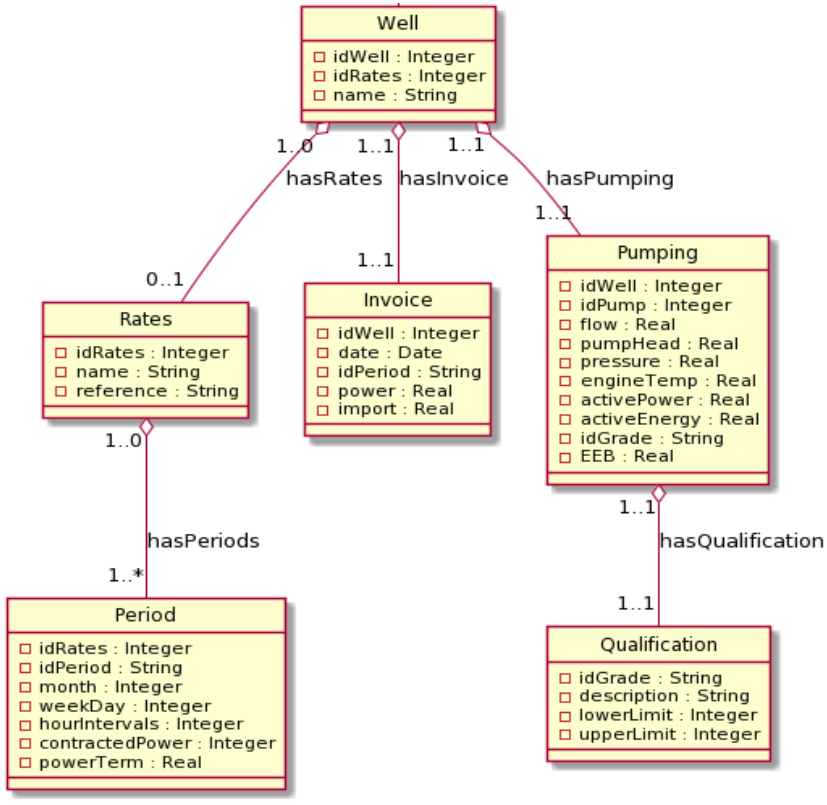
Evolution of irrigation before the platform was installed.

The analysis of the data revealed the irregularity of the irrigation system.
To have a continuous and homogeneous irrigation system, we deemed it necessary to define irrigation thresholds provided by the agricultural technicians.



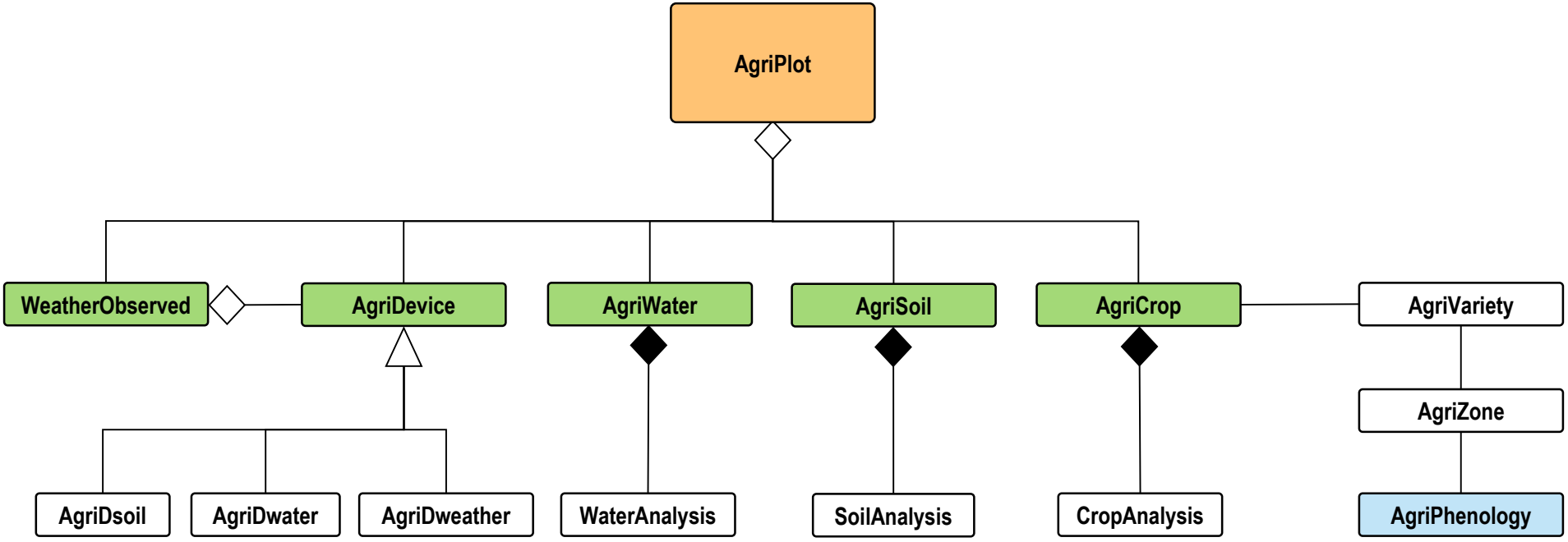
MIRAFLORES: Improved Efficiency in Irrigation Pumps



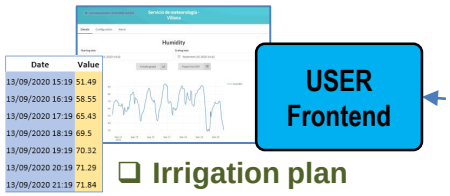


Watermed FIWARE NGSI-LD data model

The presented model is based on NGSI-LD and on the harmonized data models applied to agriculture proposed by FIWARE, adapted to new requirements defined by technicians of irrigation communities.



Watermed IoT Data Management



USER Frontend

- ❑ Irrigation plan
- ❑ Data analytics
- ❑ Historical data

NGSI-LD Broker

DB

NGSI-LD Data Model

- ❑ Weather
  - Air temperature
  - Air humidity
  - Wind speed
  - Wind direction
  - Rainfall
  - Atmospheric preasure
  - Solar radiation

Weather Service

Bridge (NGSI-LD)

DB

Backend

MQTT Agent

MQTT Server

DB Imagery

- ❑ Satellite Imagery

- ❑ Counters, sensors & controlers
  - Water counters
  - Water electrovalve controls
  - Water sensors
  - Soil moisture sensors
  - Soil conductivity sensors
  - Soil temperature sensors
  - Weather local sensors

MQTT

Datlogger

IoT Device

FIWARE NGSI-LD entity


```
{
   "@context": "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld",
   "id": "urn:ngsi-ld:AgriDevice:AgriDSoil:IPex12:00044",
   "type": "AgriDevice",
   "https://ontology.tno.nl/saref4ee/#deviceName": {
      "type": "Property",
      "value": "IPex12:00044"
   },
   "https://ontology.tno.nl/saref4ee/#manufacturerDescription": {
      "type": "Property",
      "value": "https://www.odins.es/"
   },
   "https://ontology.tno.nl/saref4ee/#serialNumber": {
      "type": "Property",
      "value": "IA0201E16000100044"
   },
   "category": {
      "type": "Property",
      "value": "Soil"
   },
   "conductivity": {
      "type": "Property",
      "value": 0.17
   },
   "humidity": {
      "type": "Property",
      "value": 8.82
   },
   "temperature": {
      "type": "Property",
      "value": 22.1
   }
}
```

Watermed User Input Data Management

USER Frontend

NGSI-LD Broker

DB

Services (Irrigation Planning)

- Irrigation plan
- Historical data

NGSI-LD Data Model

Bridge (NGSI-LD)

USER Frontend (Input data)

Backend

DB

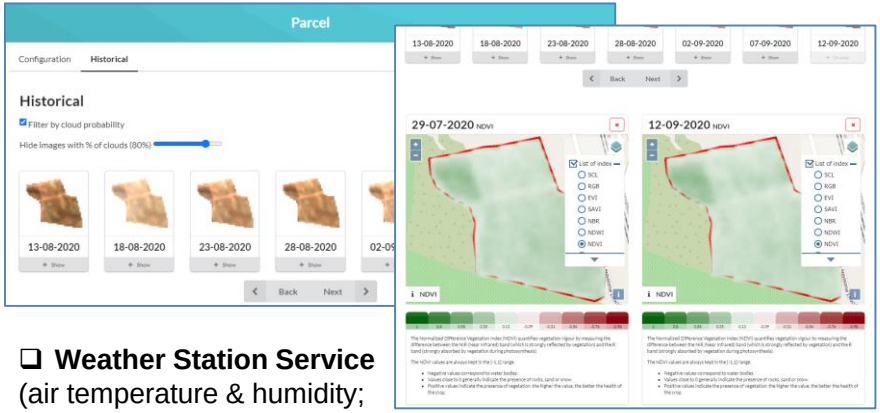
- **Parcel** (area, location, etc.)
- **Crop** (type, phenology, etc.)
- **Soil** (type, composition, etc.)
- **Irrigarion system** (type, emitters, etc.)
- **Crop plants analytics**
- **Soil analytics**
- **Water analyticis**
- **IoT devices** (location, configuration, etc.)

FIWARE NGSI-LD entity

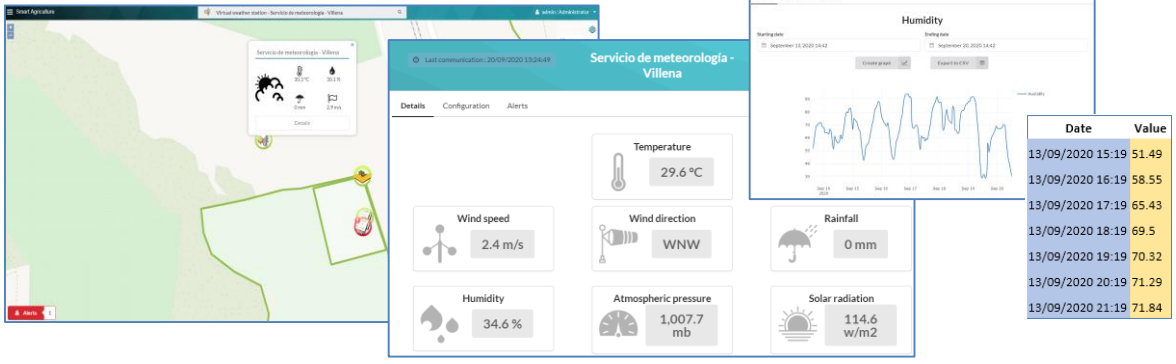

```
{
  "@context": {
"createdDate": "http://purl.obolibrary.org/obo/NCIT_C164483",
"irrigationProcess": "http://purl.obolibrary.org/obo/AGRO_00000006",
"testRetestReliability": "http://purl.obolibrary.org/obo/NCIT_C78689"
"emittersPerPlant": "http://aims.fao.org/aos/agrovoc/c_37294",
"sprinklerDistance": "http://purl.obolibrary.org/obo/PATO_0045014" // distance
"waterConductivity": "https://opendata.inra.fr/EOL/page/EOL_0000032"
  },
  "properties": {
    "createdDate": {
        "type": "Property",
        "value": "2017-01-01T01:20:00Z“ },
    "irrigationProcess": {
        "type": "Property",
        "value": "sprinkler“ },
    "testRetestReliability": {
        "type": "Property",
        "value": 8 },
    "emittersPerPlant": {
        "type": "Property",
        "value": 2 },
    "sprinklerDistance": {
        "type": "Property",
        "value": 2 },
    "waterConductivity": {
        "type": "Property",
        "value": 2 },
    "hasWaterQualityObserved": {
        "type": "Relationship",
        "object": "urn:ngsi-ld:429d1338-awwq-11e8-b90a-d3e34ceb73df “ }
  }
}
```

Watermed Services, Integrated Data and Frontend

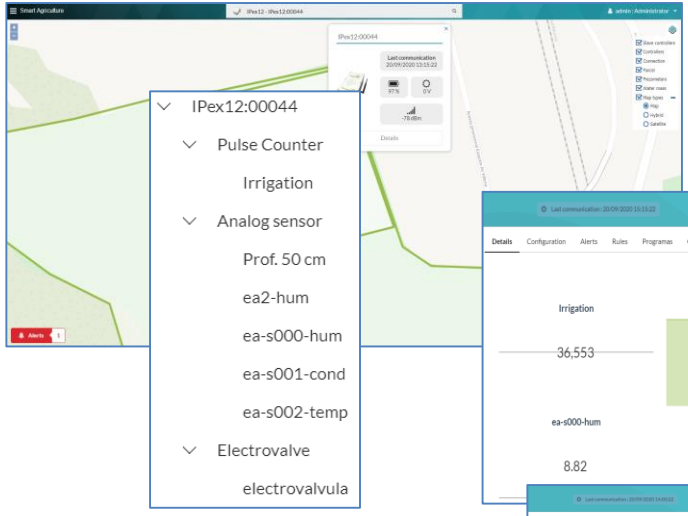
❑ **Satellite Imagery Analysis**
(SCL, RGB, EVI, SAVI, NBR, NDWI, NDVI and NDMI)



❑ **Weather Station Service**
(air temperature & humidity; wind speed & direction; rainfall; atmospheric preasure; solar radiation)



Date	Value
13/09/2020 15:19	51.49
13/09/2020 16:19	58.55
13/09/2020 17:19	65.43
13/09/2020 18:19	69.5
13/09/2020 19:19	70.32
13/09/2020 20:19	71.29
13/09/2020 21:19	71.84



❑ **Counters, probes & controlers**
Water counters;
Water electrovalve controls,
Soil probes (moisture, conductivity & temperature)

Date	Value
16/09/2020 0:15	21.84
16/09/2020 0:30	21.84
16/09/2020 0:45	21.84
16/09/2020 1:00	21.84
16/09/2020 1:15	21.84
16/09/2020 1:30	21.84
16/09/2020 1:45	21.84
16/09/2020 2:00	21.64
16/09/2020 2:15	21.64

Data Analytics

INPUT DATA

❑ User input data
- Parcel (area, location, etc.)
- Crop (type, phenology, etc.)
- Soil (type, composition, etc.)
- Irrigarion system (type, emitters, etc.)
- Crop plants analytics
- Soil analytics
- Water analyticis
- IoT devices (configuration, etc.)

❑ Counters, sensors & controlers
- Water counters;
- Water electrovalve controls,
- Water sensors,
- Soil moisture sensors,
- Soil conductivity sensors,
- Soil temperature sensors.
- Weather local sensors.

❑ Weather
- Air temperature & humidity;
- Wind speed & direction;
- Rainfall;
- Atmospheric preasure;
- Solar radiation.

❑ Satellite Imagery

DATA ANALYTICS

❑ Historical Data Analysis
- Min, max, average values in periods
- Water irrigation in periods,
- Wind bursts in periods,
- Sun hours/day,
- Cold hours/day (Utah, dinamic,..),
- Accumulated degrees/day,
- Thermal integral in period,
- User defined agronomic formulas.

❑ Satellite Imagery Analysis
- SCL,
- RGB,
- EVI,
- SAVI,
- NBR,
- NDWI,
- NDVI,
- NDMI.

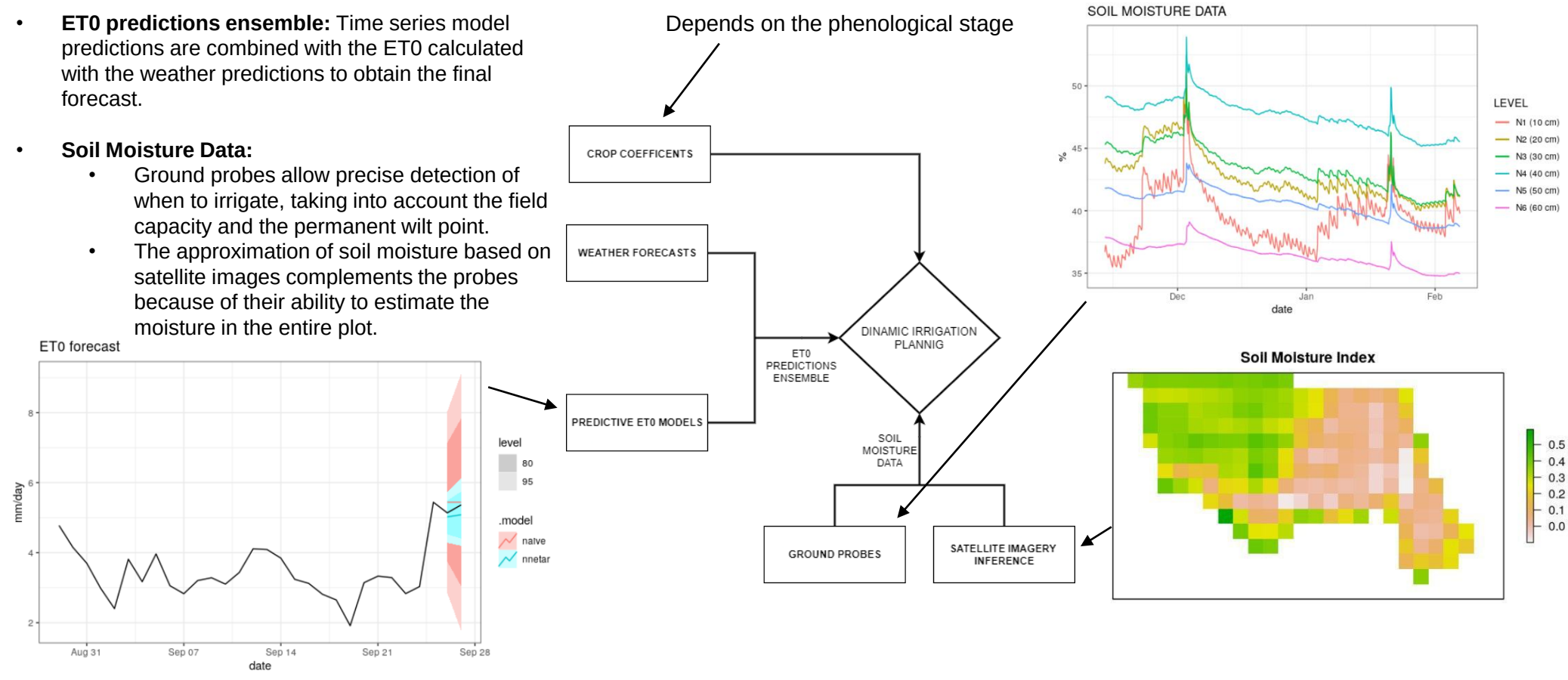
❑ Prediction and estimation
- Evapotranspiration (Eto),
- Soil moisture,
- Irrigation planning,
- Water balance model.

Data Analytics

Data analysis allows for accurate short-term irrigation planning based on various techniques:

- **ET0 predictions ensemble:** Time series model predictions are combined with the ET0 calculated with the weather predictions to obtain the final forecast.

- **Soil Moisture Data:**
  - Ground probes allow precise detection of when to irrigate, taking into account the field capacity and the permanent wilt point.
  - The approximation of soil moisture based on satellite images complements the probes because of their ability to estimate the moisture in the entire plot.



DEMETER Agriculture Information Model

DEMETER Agriculture Information Model (AIM)

- AIM follows the 3-layer NGSI-LD metamodeling approach, including:
  - a property graph metamodel layer (based on RDF/RDFS),
  - a layer of cross-domain ontologies,
  - domain/application-specific ontologies.
- This approach is an ETSI standard, which mission is to facilitate the exchange of information between end-users, Smart Cities' databases and the IoT.
- AIM implements the cross-domain and domain/application layers by reusing existing standards and/or known ontologies/vocabularies as much as possible from scratch, thus implementing semantic reference.
- AIM defines an agriculture model module/profile as a JSON-LD @context, which defines the terms used in DEMETER by reusing existing standards and/or well-known ontologies/vocabularies.

AIM JSON-LD @context example.
Reusing FOODIE's ontologie/vocabulary.

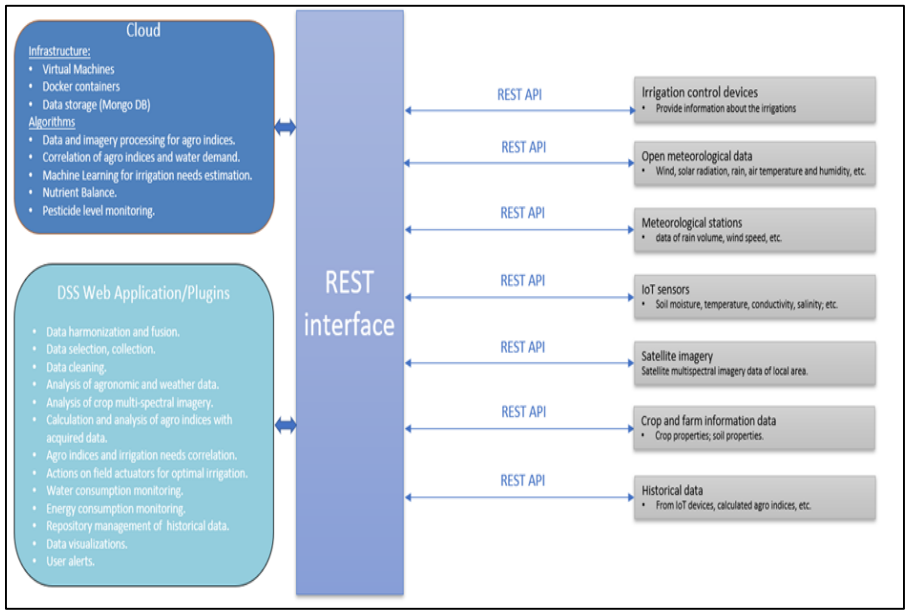
```
"@context": {
        "xsd" : "http://www.w3.org/2001/XMLSchema#",
        "Nutrients": "http://foodie-cloud.com/model/foodie#ProductNutrients",
        "Plot": "http://foodie-cloud.com/model/foodie#Plot",
        "DoseUnit": "http://foodie-cloud.com/model/foodie#DoseUnit",
        "TreatmentPlan": "http://foodie-cloud.com/model/foodie#TreatmentPlan",
        "ManagementZone": "http://foodie-cloud.com/model/foodie#ManagementZone",
        "Intervention" : "http://foodie-cloud.com/model/foodie#Intervention",
        "CropSpecies" : "http://foodie-cloud.com/model/foodie#CropSpecies",
        "Treatment" : "http://foodie-cloud.com/model/foodie#Treatment",
        "Holding" : "http://inspire.ec.europa.eu/schemas/af/3.0#Holding",
        "code" : "http://foodie-cloud.com/model/foodie#code",
        "creationDateTime" : {
                        "@id" : "http://foodie-
cloud.com/model/foodie#creationDateTime",
                        "@type": "xsd:dateTime"
        },
        "cropSpecies" : {
                        "@id" : "http://foodie-
cloud.com/model/foodie#cropSpecies",
                        "@type": "@id"
        },
        "originType" : {
                        "@id" : "http://foodie-
cloud.com/model/foodie#originType",
                        "@type": "@id"
        },
        "zoneAlert" : {
                        "@id" : "http://foodie-cloud.com/model/foodie#zoneAlert",
                        "@type": "@id"
        },
        "holdingZone" : {
                        "@id" : "http://foodie-
cloud.com/model/foodie#holdingZone",
                        "@type": "@id"
        }
}
```

DEMETER Pilot – Services and DSS

Pilot 1.1&1.2 – Water Savings & Smart Energy Management in Irrigated & Arable Crops

- The objective is to increase the production of irrigated crops whilst saving water and energy.
- This can be achieved improving the automation of the irrigation zones through interoperable remote-control systems and robust management systems adapted to the conditions required by the irrigated agriculture.
- DEMETER Decision Support Services (DSS) will help farmers:
  - The applications use heterogeneous data coming from IoT Sensors, control systems, satellites and other sources, using DEMETER AIM data model and data-fusion.
  - The data is consumed to perform image processing, data analytics and machine learning for the estimation of irrigation needs by a water balance model.
  - The DSS will make use of this data processing it to provide the needed decision support to farmers.

Requirements Diagram



Conclusion

Opportunity to DT in the sector based on IoT platforms and data models

- **Scalability**: the millions of sensors continuously generating large amounts of information.

- **Heterogeneity**: there is a wide variety of sensors.

- **Dynamism**: the high speed of generation produced the need to create data models that allow better use and dissemination of the information from these devices.

Related projects

DEMETER has received funding from the European Union's **Horizon 2020 Research and Innovation Programme** under Grant Agreement N° 857202

IoTCrawler has received funding from the European Union's **Horizon 2020 Research and Innovation Programme** under Grant Agreement N° 779852

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