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# Introduction

## Document Objectives and Scope

The objective of this document is to provide data model requirements for the Water-M project. These models aim to assume local and Global data model integration of water management platform.

### Purpose

This document describes the models concerning the data model and ontology with class hierarchy for Water-M project. The goal of the data model is to define the local data and general data which communicate with other levels of water-m platform.

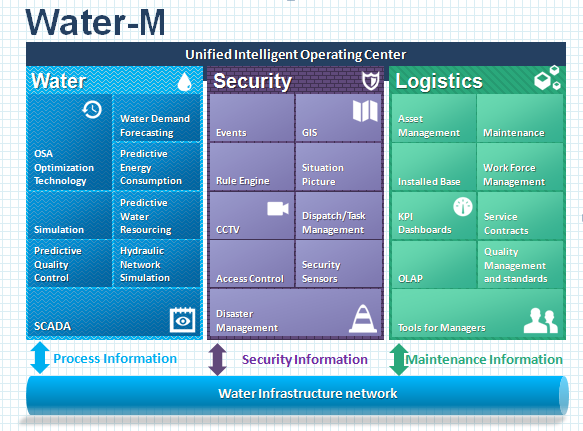
### Scope

In the Water-M project a system has to be designed to support requirements in business scenario.

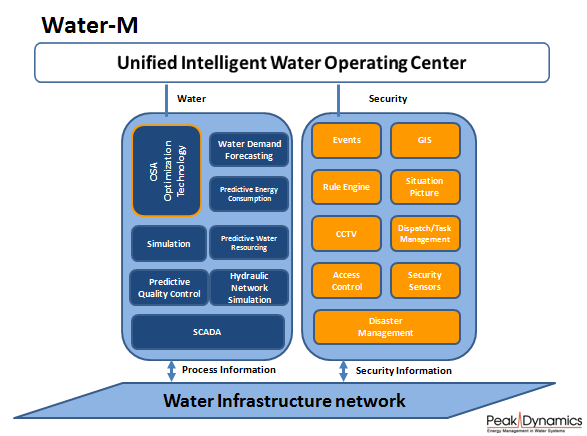
### List of Definition

This section contains the definition of all used terms, acronyms and abbreviation in this document.

# Water Management System Chart



**3 Water Management Operating**



# 4 Data Models

Infrastructure of Water-M platform is complex system thus we need local definition and general definition of the data models.According to system architecture scope of the water-m platform is to provide solution for central collection of the related data such as pressure,control parameters,raw data for CEP engine,alarms,events.

Each plant may have their own scada systems in order to control the water management thus we need to define these parameters in local database systems and then system should integrate with other relevant systems.

## 4.1 Definition of data models

* **Local Database structure**
* **Global Database structure**

## 4.1.1 Local Database structure

This part will have plant’s infrastructure for waste water monitoring communication with hardware network and control parameters.

So we need some tables to store local entity of the plant to define and communication with global structure.

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **Machines** | Definition of the Machines which works in the plant and can control by the system. | Aim of this definition is to known by the water-m platform and what duty in the system and how it is control in which cases. | M\_id,  M\_Definition,  M\_Location,  M\_Workinghours,  M\_NoWorkdays,  M\_Sensorid,  M\_SerialNumber |
| **Parameters** | Definition of the parameters which values will be controlled and in which cases besides upper and lower limits. | Controlling the parameters with their upper and lower limits according to EU standards. | P\_id,  P\_Name,  P\_GlobeName,  P\_Frequency,  P\_inputvalue1,  P\_inputvalue2,  P\_SampleValue1,  P\_SampleValue2,  P\_SampleOutputValue1,  P\_SampleOutputValue2 |
| **QualityType** | Definition of the Quality measurement type with respect to EU standards with their needs and not needs and grouping of the quality type like Chemical,Microbiological ,Biological. | Aim of this table is to define and grouping control parameters i.e.  Chemical–Conductivity  Chemical–ORP(Redox)  Microbio–UV254nm Ultr.  Microbio –VIS420nm Vis.Absorbence | q\_id,  q\_type,  q\_typename,  q\_controlparametercode,  q\_controlpname |
| **Plant** | Definition of the plant | Aim of this table is to define Location,country,City | Plnt\_id,  Plnt\_name,  Plnt\_Location,(GEO),  Plnt\_Country,  Plnt\_City |
| **ProtocolType** | Definition of the protocol for the communication with local scada or other systems. | Aim of this table is to define which protocol,what is ip address,gateways etc.. | Protocol\_id,  Protocol\_Name,  Protocol\_port,  Protocol\_ip,  Protocol\_gateway |
| **Sensors** | Definition of the sensors which data comes from which sensors with its technical properties | Aim of this table is to define which sensor is send which data i.e.  pH sensor – sensor id  Redox sensor-sensor id | s\_id,  s\_name,  s\_location,  s\_plcbrand,  s\_plcip,  s\_procolid,  s\_plcipnumber,  s\_plcgateway,  s\_plcport,  s\_plcscanrate |
| **TagDefinition** | Definition of the Tag means address of the PLC in which data comes from which address from the existing SCADA system | Aim of this table is to define address of the sensor data in PLCs which is running in the scada system. | Tag\_id,  Tag\_number,  Tag\_location,  Tag\_channel,  Tag\_device,  Tag\_name,  Tag\_address,  Tag\_datatype,  Tag\_accesstype,  Tag\_scanrate |
| **Rules** | This definition can be changed according to their requirements all controlable rules can be stored in this structure. | Aim of this table is to define in which case parameters will be controlled and what action will be taken and in which situation data will communicate with global structure and only active rules will be valid for this structure | Rule\_id,  Rule\_name,  Rule\_type,  Rule\_typenumber,  Rule\_Control1,  Rule\_Control2,  Rule\_action,  Rule\_actionnumber,  Rule\_active |
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## 4.1.2 Global Database structure

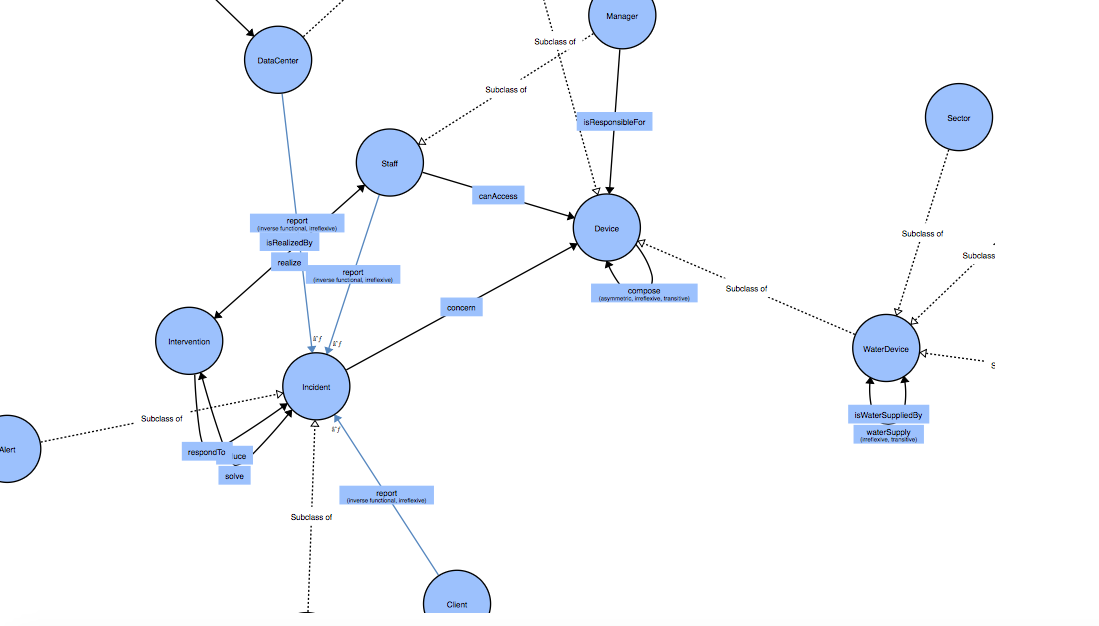
Global Database structure can be changed into one structure according to their requirements but must be one structure with communicates API in order to send data to Enterprise level.This structure will be message base in order to send data other relevant system like Enterprise Bus service and CEP engine.

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **SensorMeasureMessage** | This table will define structure of the sensor measure data. | Aim of this structure is to communicate with Global structure and Local ,Local data will be send by using this structure via API to the enterprise level. | Source,  Scope,  Temporality,  Value,  Type of measure,  Sensor ID,  Date,  Resource |
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# 4.1.3 Class Hierarchy

Here we provide the list of WaterM classes and their hierarchy.

* Client
  + Collectivity
  + DomesticClient
  + IndustrialClient
* Device
  + Electric Device
    - Data Center
    - Fan
    - Generator
    - Pump
    - Actuator
      * OnOffRelay
    - Sensor
      * Environment Sensor
        + AirSensor
        + DeviceThermometer
        + OverflowSensor
        + PresenceSensor
        + State Sensor
      * LevelMeter
      * Sonometer
      * Thermometer
        + DeviceThermometer
        + WaterThermometer
      * WaterSensor
        + Flowmeter
        + Manometer
        + Meter
        + WaterQualitySensor
        + ImpulseMeter
        + PressureMeter
      * Photosensor
      * Humidity
      * LightLevel
  + Tank
  + Water Device
    - Bladder
    - Controller
      * FlowLimiter
      * PressureLimiter
      * PumpingGroup
        + Accelerator
        + Booster
        + PumpingStation
    - FireHydrant
    - Pipe
    - Reservoir
      * Basin
      * WaterTower
    - Sector
      * PrivateSector
      * PublicSector
    - Valve
* Incident
  + //Alert
    - EnvironmentAlert
      * IntrusionAlert
      * UnSafeEnvironmentAlert
      * FreezingAlert
      * OverheatingAlert
      * FloodingAlert
    - LeakAlert
    - MalfunctionAlert
      * DeviceBreakdownAlert
      * ElectricDisruptAlert
    - WaterAlert
      * FlowAlert
      * WaterAlert
      * PressureAlert
      * WaterQualityAlert
  + Claim
    - OverConsumption
    - WaterShortage
    - PoorWaterQuality
* Intervention
  + ConsumableRenewal
  + Installation
  + Measure
  + Replacement
* Measurement
  + NoiseMeasure
  + TemperatureMeasure
  + WaterMeasure
    - FlowMeasure
    - PressureMeasure
    - VolumeMeasure
* MeasureUnit
  + EnergyUnit
  + FlowUnit
  + NoiseUnit
  + PressureUnit
  + TemperatureUnit
  + VolumeUnit
* Staff
  + Manager



# 4.1.4 WaterM Data-Model for Use-cases 4 and 5: Performance Monitoring of Water Distribution Network

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **Client** | This is a general client of the water distribution company. | This class allows clients to have iDs, visualize their consumption, their accounts, etc. | id,  Definition,  Address,  Name,  Login,  AccessType,  Incident,  Dashboard  Contract  Meter |
| **Client::Collectivity** | Collectivity, a subtype of client. Typically, it remains the organizing entity of the service even though it chooses to delegate the water-distribution service to a private company | Represents the collectivity, allows it to ensure the quality of the water. It receives information from national, provincial bodies or users, analyze this information and may report them to the water agency, the state or to the european level.  The collectivity may also raise alerts | Delegated to,  Zone, |
| **Client::Domistic Client** | This class represents the individual user. | Allows the user to monitor her consumption, monitor the water quality, allows to provide her feedback, | Inhabitants,  UserProfile |
| **Client:IndustrialClient** | This is an industrial client with relatively bigger needs than individual users | Allows the industrial client to monitor her consumption, monitor the water quality, gives her feedback, detects and report leaks, etc. | Meter, |

|  |  |  |  |
| --- | --- | --- | --- |
| **Device** | This is a generic device, it can be a water device, electric device, etc. | Allows to model all types of devices | ID,  Name,  Location,  Brand,  IP,  Number,  Gateway,  Port,  ReadingFrequency,  InstallationDate,  Type,  OperatingRange,  SurvivalRange |
| **Device::ElectricDevice** | is defined as a sub-class of the Device concept and describe components which have an electrical connection (Sensor, Generator, Pump, etc.) | Models generic electric devices | PowerType,  PowerConsumptionProfile, |
| **Device::WaterDevice** | the set of equipment composing the water distribution network (pipes, tanks, etc.) | Models generic water devices | WaterDeviceType |
| **ElectricDevice::Sensor** | is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.  Sensor is categorized by a set of properties:   * Accuracy: the agreement between the measurement result and the true value * Precision: the error of a measurement series or the scattering around an average value. * Selectivity: change in the measurement signal per concentration unit of the analyses * Detection limit: the lowest concentration value that can be detected by the sensor, following a priori defined signal to noise ration * Dynamic range: the concentration range between the detection limit and the upper limiting concentration * Response time: the time to respond from a zero concentration to a step change in concentration | Models generic sensor | Id,  Latitude,  Longitude,  Accuracy,  Precision,  Selectivity,  Dynamic range,  Response time,  Description,  Battery level, |
| **Sensor::Thermometre** | indicates the degree or intensity of heat present in a substance or object | measures temperature in a defined location | Temperature, TemperatureUnit, |
| **Sensor::Flowmeters**  **Sensor::MeterSensor** | indicates flow rate | measures the flow rate of water | flow rate,  Unit, |
| **Sensor::Manometer** | indicates Air Pressure | measures air pressure | Pressure  Unit |
| **Sensor::WaterQuality** | indicates water quality | measures water quality using different metrics | PH, conductivity, resistivity, salinity, dissolved oxygen and temperature readings |
| **ElectricDevice::Pump** | generic class for water pumps | It is used to increase pressure and flow rate | PumpType,  PumpingUnitStatus(operating / stop),  PumpRotationSpeed,  PressureHydrophoreTank (if booster),  InflowSpeed,  Outflow Speed,  InletPressure, OutletPressure,  Temperatures(local, motor, water),  FuelLevel,  FuelConsomption,  OilTemperature,  OperatingDuration |
| **WaterDevice::Firehydrant** | generic class for firehydrant | Protection against fire is one of the skills provided by public officials, which is commonly provided by hydrants fed by water systems. To be fully effective the hydrant must be able to issue a certain flow at a minimum pressure (in France at least 60 m³ / h at 1 bar pressure or more depending on the risks to be covered).  The fire hydrant post is equipped with a foot valve for maintenance. The hydrants are usually protected in locked chests whose keys are with the rescue services.  Often these devices are not metered. In France any consumption of drinking water should be charged to the user with the exception of that used for the defense against fire. The water used is treated as a leak from the network while in fact it has been used for a specific purpose.  These facilities must be operational at all times. Irregular practices are sometimes observed. The boxes are opened, the valves are opened and it also even happens that the post is damaged (in case of a collision). | FootValveStatus(open, closed, pinched),  FlowRate,  CurrentPressure,  LidStatus(open or closed),  HydrantPostStatus(upright or inverted) |
| **WaterDevice::Pipe** | Generic class for Water Pipes | models the water pipes, their type, capacity, etc. | Diameter,  EndCoordinates, |
| **WaterDevice::Reservoir** | Generic class for WaterReservoir | models reservoir types, capacity, etc. | Capacity,  CurrentWaterLevel,  WaterPressureAtExit,  IntrusionSensor,  InputFlowRate,  OutputFlowRate,  Height,  OverflowDetect,  ResidualRateDisinfectantInDistributedWater  Turbidity,  LocalTemperature  TemperatureOfDistributedWater,  VentilationStatus(on or off),  Valves,  PowerFailureDetectionSensor |

|  |  |  |  |
| --- | --- | --- | --- |
| **Measurement** | Is the act of carrying out a measurement procedure to estimate a value for a property | Models a generic act of measuring | MadeBy (Sensor),  Procedure,  MeasuredProperty,  OriginatedBy,  HasAResult,  MeasurementFrequency  ResultTime |
| **Measurement:NoiseMeasurement** | A measurement of noise at a given place in the network | A relative increase in the noise measured in the network) maybe used to detect if there is a leak in the system (since the leak). Thus, a comparative analysis of noise in terms of a noise "average" to determine or locate a leak | AverageNoise,  Type,  NoiseUnit |
| **Measurement:TemperatureMeasure** | Measure the temperature at a given place in the network | Monitoring the temperature is vital to assess the conditions of the networks and the quality of the distributed water. Temperature should be measured in pipelines, reservoirs, etc. | AcceptableTemperatrueValues,  AverageTemperature,  TemperatureUnit |
| **Measurement:WaterMeasure** | This class represents a generic water measurement | The purpose is to measure the flow, the pressure, or the volume | Type, |
| **WaterMeasure:FlowMeasure** | This class represent a measurement of conducted to measure the water flow (m3/sec) at a given position in the pipelines or in a reservoir | Ensuring a minimum water flow is vital to ensure a comfortable distribution for users. On the other hand high flow is harmful for the network. For this reason flowrate measurement should be conducted | FlowRateUnit,  AcceptableRange,  AverageFlowRate |
| **WaterMeasure:PressureMeasure** | This class represent a measurement of conducted to measure the water pressure (typically measured in bars) at a given position in the network | Typically, a minimum pressure is imposed. A comfortable pressure for the user is 3 bars. For this reason, the pressure should be measured at different places on the network | PressureUnit  AcceptableRange,  AveragePressure |
| **WaterMeasure:VolumeMeasure** | This class represent a measurement of conducted to measure the water volume (typically measured in M3) | Monitoring the volume of water traversing each sector allows to detect leaks, hence the need of volume measurements | VolumeUnit |
| **TODO** |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **Client** | This is a general client of the water distribution company. | This class allows clients to have iDs, visualize their consumption, their accounts, etc. | id,  Definition,  Address,  Name,  Login,  AccessType,  Incident,  Dashboard  Contract  Meter |
| **Client::Collectivity** | Collectivity, a subtype of client. Typically, it remains the organizing entity of the service even though it chooses to delegate the water-distribution service to a private company | Represents the collectivity, allows it to ensure the quality of the water. It receives information from national, provincial bodies or users, analyze this information and may report them to the water agency, the state or to the european level.  The collectivity may also raise alerts | Delegated to,  Zone, |
| **Client::Domistic Client** | This class represents the individual user. | Allows the user to monitor her consumption, monitor the water quality, allows to provide her feedback, leaks repots etc.. | Inhabitants,  UserProfile |

# 4.1.5 WaterM Data-Model for Use-cases 2 Development of Water Management and Flood Risk Prevention Platform and 3: River Tele-monitoring

**Class Hierarchy**

The complete list of the classes:

* Client
  + Collectivity
  + IndustrialClient
* Device
  + Gateway
  + RTU
  + Data presentation server
  + Sensors
    - Water temperature sensor
    - Water level sensor
    - Pressure sensor
* Incident
  + Alert
    - EnvironmentAlert
      * Weather alert
    - MalfunctionAlert
      * DeviceBreakdownAlert
* Intervention
  + - Installation
    - Measure
    - Replacement
* Measurement
  + WaterMeasure
    - Temperature Measure
    - Level Measure
    - Pressure Measure
* MeasureUnit
  + TemperatureUnit
  + LevelUnit
  + PressureUnit
* Staff
  + Manager

**WaterM Data-model for UseCases 2 and 3**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **Client** | A general client of the water monitoring system company. | This class allows clients to visualize the parameters measured by sensors, temperature, level and pressure, in the form of a table or diagram, wich are at the free choise of users. | Address  Name  Login  AccessType |
| **Client: Collectivity** | The entity that organizes the water parameter viewing service. | Receives information about the status of the monitoring system and reports to ANAR and dispatching systems. | Delegated to,  Zone |
| **Client: DomesticClient** | This class represents the ordinary users. | Allows users to view the temperature, pressure and water level along a river and its tributaries. | The inhabitants around the river and its tributaries,  UserProfile |
| **Client: IndustrialClient** | This type of client needs more accurate informations about water parameters. | Allows monitoring of water parameters for reporting to national institutions. | Metering |
| **Device** | A general name, in this case it is a water device. | Allows to model all types of devices | ID  Name  Location  Brand  IP  Gateway  Port  Type  OperatingRange  SurvivalRAnge |
| **Device: Sensors** | Technical devices that react qualitatively or quantitatively to certain physical or chemical properties of the environment. It can measure, record and transmit physical parameters that are transformed into a signal that can be read by an observer through a tool or a web platform.  Sensors must have several properties:   * Accuracy: the measured and transmitted value should be as close as possible to the real one. * Precision: the quality of the measurements should be the best. * Measurement and transmission time: Ideally, data should be transmitted in real time, after the measurement. | Models generic sensor. | ID  Latitude  Longitude  Accuracy  Precision  Measurement and transmission time |
| **Sensor: WaterTemperature** | Indicates the degree of heat present in the water. | Measures water temperature in a specified location. | Temperature  TemperatureUnit |
| **Sensor: WaterLevel** | Indicates the water level. | Measures the water level in a specified location. | Level  LevelUnit |
| **Sensor: WaterPressure** | Indicates the water pressure. | Measures the water level in a specified location. | Pressure  PressureUnit |
| **Incident** | Unexpected accident that occurs at the system level and causes damages. It may be a technical failure, from natural causes or it can be caused by people. | Repairing faults in the water monitoring system. | Incident,  Abnormal values observed on the table,  A client sends a notification to the water monitoring company |
| **Intervention** | Process of repairing the malfunctions. | Detecting defects and repairing the system in a short time. | Moving to the scene of the incident,  Finding faults,  System repair,  Putting the system into operation |
| **Measurement**  **Measurement: WaterMeasure** | It is the process of obtaining one or more physical values, relative to a unit of measure. | Measures water parameters. | Metering |
|  |  |
| **WaterMeasure: Temperature** | Indicates the temperature of water at a specific place. | The temperature is measured and can be seen if it is within the normal limits of each season. | TemperatureUnit |
| **WaterMeasure: Level** | Indicates the level of water at a specific place. | The level is measured and can be seen if it is within the normal limits of each season. | LevelUnit |
| **WaterMeasure: Pressure** | Indicates the pressure of water at a specific place. | The pressure of the water is measured and can be seen if it is within the normal limits. | PressureUnit |

5 Water-M Ontology and Data-Model

The .ttl file for the Ontology can be found here:

https://github.com/WaterMOntology/WaterMOntology/blob/master/WaterM.ttl

Below is the description of different classes

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description** | **Purpose** | **Structure** |
| **Client** | This is a general client of the water distribution company. | This class allows clients to have iDs, visualize their consumption, their accounts, etc. | id,  Definition,  Address,  Name,  Login,  AccessType,  Incident,  Dashboard  Contract  Meter |
| **Client::Collectivity** | Collectivity, a subtype of client. Typically, it remains the organising entity of the service even though it chooses to delegate the water-distribution service to a private company | Represents the collectivity, allows it to ensure the quality of the water. It receives information from national, provincial bodies or users, analyze this information and may report them to the water agency, the state or to the european level.  The collectivity may also raise alerts | Delegated to,  Zone, |
| **Client::Domistic Client** | This class represents the individual user. | Allows the user to monitor her consumption, monitor the water quality, allows to provide her feedback, | Inhabitants,  UserProfile |
| **Client:IndustrialClient** | This is an industrial client with relatively bigger needs than individual users | Allows the industrial client to monitor her consumption, monitor the water quality, gives her feedback, detects and report leaks, etc. | Meter,  ConnectionType |

|  |  |  |  |
| --- | --- | --- | --- |
| **Device** | This is a generic device, it can be a water device, electric device, etc. | Allows to model all types of devices, get their name, location, ID, reading frequency, installation date, etc. | ID,  Name,  Label,  Location,  Brand,  IP,  Number,  Gateway,  Port,  ReadingFrequency,  InstallationDate,  Type,  OperatingRange,  SurvivalRange |
| **Device::ElectricDevice** | is defined as a subclass of the Device concept and describes components which have an electrical connection (Sensor, Generator, Pump, etc.) | Models generic electric devices | PowerType,  PowerConsumptionProfile, |
| **ElectricDevice:DataCenter** | This class is a usb class of electric device, it models a data center or servers used to stock and process data | A data center is used to stock and process data collected by the sensors |  |
| **ElectricDevice:Fan** | The fan installed in the reservoir. The fan’s role is to ensure air circulation in order to guarantee the purity of the water in the reservoir | Probe the status of the ventilation system and check out the air quality in the reservoir | RPM |
| **ElectricDevice:Generator** | When electricity is not available from an electricity provider, a generator generates the electricity required to power the pumping station. Even in this case. | This class models the electricity generator. The latter should be monitored to ensure that it is operational when needed | Frequency,  Capacity |
| **ElectricDevice::Pump** | Generic class for water pumps | It is used to increase pressure and flow rate | PumpType,  PumpingUnitStatus(operating / stop),  PumpRotationSpeed,  PressureHydrophoreTank (if booster),  InflowSpeed,  Outflow Speed,  InletPressure, OutletPressure,  Temperatures(local, motor, water),  FuelLevel,  FuelConsomption,  OilTemperature,  OperatingDuration |
| **ElectricDevice::Actuator** | An actuator is a device that implements some actuating procedure, and has thus an impact on the physical world. | Models generic actuator | Latitude,  Longitude,  Accuracy,  Precision,  Selectivity,  Dynamic range,  Response time,  Description,  ActuationProcedure,  TargetValue,  TargetUnit |
| **Actuator::OnOffRelay** | is a subclass of Actuator | Models on-off relay to switch electricity on and off for light management | State |
| **ElectricDevice::Sensor** | is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing .  Sensor is categorised by a set of properties:   * Accuracy: the agreement between the measurement result and the true value * Precision: the error of a measurement series or the scattering around an average value. * Selectivity: change in the measurement signal per concentration unit of the analyse * Detection limit: the lowest concentration value that can be detected by the sensor, following a apriori defined signal to noise ration * Dynamic range: the concentration range between the detection limit and the upper limiting concentration * Response time: the time to respond from a zero concentration to a step change in concentration | Models generic sensor | Latitude,  Longitude,  Accuracy,  Precision,  Selectivity,  Dynamic range,  Response time,  Description,  Batterie level,  Unit |
| **Sensor:EnvironmentSensor** | This class represents a generic environment sensor | The environment sensor measures some feature of interest in the environment |  |
| **EnvironmentSensor:AirSensor** | This class is subclass of the environment sensor, it senses air quality in a given facility or location | The quality of the air in a reservoir or a facility can be an important indicator of the water quality | AirQuality |
| **EnvironmentSensor:DeviceThermometer** | This class is a subclass of the environment sensor class, it represent a special type of thermometer measuring the temperature of a device | Typically, each device on the network its own specifications stipulating the thresholds of tolerable temperatures | DeviceTemperature |
| **EnvironmentSensor:OveflowSensor** | This is a subclass of environment sensor, it represents an overflow Sensor | An overflow sensor detects if the water flow exceeds a predefined threshold, in this case, it can trigger an event | Threshold,  Trigger |
| **EnvironmentSensor:PresenceSensor** | This is a subclass of the environment sensor, it models a presence sensor | Sensing the presence is essential to detect intrusion in a facility | Status |
| **EnvironmentSensor:StateSensor** | This is a subclass of the environment sensor. | binary state sensor which send a signal to tell that a (complex) device is functionning | State |
| **Sensor:LevelMeter** | This is a subclass of sensor meter. | This class senses a level of a liquid (can be water or fuel) | Level |
| **Sensor:SonoMeter** | This is a subclass of sensor meter | Sensing the amount of noise | Noise |
| **Sensor:Thermometer** | indicates the degree or intensity of heat present in a substance or object | measures temperature in a defined location | Temperature, TemperatureUnit, |
| **Thermometer:DeviceThermometer** | This class is a subclass of the environment sensor class, it represents a special type of thermometer measuring the temperature of a device | Typically, each device on the network has its own specifications stipulating the thresholds of tolerable temperatures | DeviceTemperature |
| **Thermometer:WaterThermometer** | This is a subclass of the thermometer class, it measures the temperature of water | Measuring the water temperature can be useful to assess the water quality and the network quality | WaterTemperature |
| **Sensor:WaterSensor** | This is a generic class of water sensor. Its derived classes can be flowmeters, etc. |  |  |
| **Watersensor:Flowmeters** | Indicates flow rate | It measures the flow rate of water | FlowRate |
| **WaterSensor:Meter** | General class to represent a meter | Measures different elements | Type |
| **WaterSensor::Manometer** | indicates Air Pressure | Measures air pressure | Pressure |
| **WaterSensor:ImpulseMeter** | This is a subclass of WaterMeter. Standard impulse characteristics of the flow meter are as follows: 4 imp/l, 1 imp/l, 1 impulse per 10 litres, 1 impulse per 100 litres | It is used to account flow rate and transmit the signal to the secondary control unit (e.g. dosing a pump with pulse input) | ImpulseMagnitute,  PerHowManyLiters |
| **WaterSensor:PressureMeter** | This is a water pressure meter | Provides accurate water pressure readings from the network | Pressure,  PressureUnit |
| **WaterSensor::WaterQualitySensor** | Indicates water quality | Measures water quality using different metrics | PH,  Conductivity, Resistivity,  Salinity,  Dissolved oxygen and temperature readings |
| **Sensor:Photosensor** | is a subclass of sensor | Models an analog photosensor to detect a threshold level of light | State |
| **Sensor:Humidity** | is a subclass of sensor | Models a sensor to measure humidity | Humidity |
| **Sensor:LightLevel** | is a subclass of sensor | Models a sensor to measure light level | LightLevel |
| **Device::WaterDevice** | The set of equipment composing the water distribution network (pipes, tanks, etc.) | Models generic water devices | WaterDeviceType |
| **WaterDevice::Pipe** | Generic class for Water Pipes | Models the water pipes, their type, capacity, etc. | Diameter,  EndCoordinates, |
| **WaterDevice::Firehydrant** | Generic class for firehydrant | Protection against fire is one of the skills provided by public officials, which is commonly provided by hydrants fed by water systems. To be fully effective the hydrant must be able to issue a certain flow at a minimum pressure (in France at least 60 m³ / h at 1 bar pressure or more depending on the risks to be covered).  The fire hydrant post is equipped with a foot valve for maintenance. The hydrants are usually protected in locked chests whose keys are with the rescue services.  Often these devices are not metered. In France any consumption of drinking water should be charged to the user with the exception of that used for the defense against fire. The water used is treated as a leak from the network while in fact it has been used for a specific purpose.  These facilities must be operational at all times. Irregular practices are sometimes observed. The boxes are opened, the valves are opened and it also even happens that the post is damaged (in case of a collision). | FootValveStatus(open, closed, pinched),  FlowRate,  CurrentPressure,  LidStatus(open or closed),  HydrantPostStatus(upright or inverted) |
| **WaterDevice::Reservoir** | Generic class for WaterReservoir | It models reservoir types, capacity, etc. | Capacity,  CurrentWaterLevel,  WaterPressureAtExit,  IntrusionSensor,  InputFlowRate,  OutputFlowRate,  Height,  OverflowDetect,  ResidualRateDisinfectantInDistributedWater  Turbidity,  LocalTemperature  TemperatureOfDistributedWater,  VentilationStatus(on or off),  Valves,  PowerFailureDetectionSensor |
| **Reservoir:Basin** | Subclass of reservoir | a reservoir that exploit the topography to create the pressure | Capacity,  State |
| **Reservoir:WaterTower** | This class models a “water tower” which is a special type of reservoir | To permit water delivery to consumers in good conditions, it is necessary that the difference in height between the reservoir and the housing is sufficient to have a correct pressure at the tap. The delivery of water is in general by gravity. A difference of ten meters between the reservoir and the distribution point corresponds to 1 bar of pressure. A pressure of "comfort" for the users is about 3 bar. |  |
| **WaterDevice:Bladder** | A class representing a bladder | A bladder is a flexible water pouch associated with a pump | Capacity,  State |
| **WaterDevice:Controller** | It is a generic class representing a controller. This place could be a sub-class of the class actuator of the SSN ontology. The difference between this class and the class actuator can be seen as follows: while Actuator is qualified as an object that changes the status of the system, controller is capable of changing the system status depending on measurements it has already done on the system | It is used to control some parameters to ensure their value falls into the acceptable range.  Note that this class involves a full control loop. it can have one or multiple sensors and one or multiple actuators working on the system | Actuators,  Sensors,  Position |
| **Controller:FlowLimiter** | This class represents a flow limiter. | Depending on the topology of the network, the water pressure and the water flow can be very significant. Furthermore, a break in the pipelines can cause an increase in the flow and cause very significant damages to the network. For this reason, a flow and a pressure limiter are added to the network in order to cut the water supply on the network when the flow exceeds a predefined value | FlowThreshold,  CurrentFlowValue,  TargetValue |
| **Controller:PressureLimiter** | This class represents a pressure limiter. | Depending on the topology of the network, the water pressure and the water flow can be very significant. Furthermore, a break in the pipelines can cause an increase of the flow and cause very significant damages to the network. For this reason, a pressure and a pressure limiter are added to the network in order to cut the water supply on the network when the pressure exceeds a predefined value | PressureThreshold,  CurrentPressureValue,  TargetValue |
| **Controller:Pumping group** | Models a group of pumps | The group of pumps installed to change the pressure in the  pipes in case it goes low | State |
| **PumpingGroup:accelerator** | A class that models an accelerator used to increase the pressure in the network | Sometimes while the flow rate is enough, the pressure might be too weak to ensure a comfortable distribution for users. For this reason, a pump (or multiple pumps) are positioned to pump water from upstream to downstream | State,  Inflow rate,  outflow rate,  Inpressure,  OutPressure,  Rate of energy consumption,  Presence sensor,  State of the electricity network,  Noise,  Temperature |
| **PumpingGroup:Booster** | A class that models a booster | When a booster is used, the users are provided directly by the pumps taking the water reserve and inflating a sealed bladder ensuring a minimum buffer stock. When the pressure within the bladder drops below a set value the pumps are again put in operation. | Status,  MaximumCapacity |
| **PumpingGroup:PumpingStation** | A class that models a pumping station | Depending on the topography and the perimeter served by the reservoir, sometimes it is necessary to install pumping devices allowing to increase the flow and the pressure. A pumping station is used to pump water from downstream reservoir to an upstream reservoir. The latter assumes the supply of water of its own sector | MaximumCapacity |
| **WaterDevice:Sector** | This class models a sector | Typically, network operators are concerned about: the water volumes crossing their networks, leaks, cost savings and the reduction of unbilled water volumes. | VolumePerSectionCounter,  Type |
| **Sector:PrivateSector** | This is a subclass of sector | Beyong the distribution point, the private sector begin. Private sector only follows physical laws |  |
| **Sector:PublicSector** | This is a subclass of sector | public sector follow rules and laws for public water distribution. |  |
| **WaterDevice:Valve** | A class that models a valve. The latter is used to divide the network | After leaving the reservoir, the network is divided in sections to serve all users of the service. Each section usually starts with a block valve to isolate a section of the network for its particular maintenance. | Status (Opened/Closed),  OpenningPercentage |
| **Incident** | This is a generic class that models an incident. Subclasses include Alert (reported by the staff) or claim reported by a client |  | Time,  Subject,  Position,  Reporter,  Report,  Status (solved or not) |
| **Inciddent:Alert** | This is a generic class to represent an alert | An alert is reported by one of the staff members or by a data-analysis process | OriginType(Staff or Data-analysis) |
| **Alert:EnvironmentAlert** | A subclass of a class to model an environment alert. | An environment alert is an alert pertaining to an alert occurring in the surrounding environment |  |
| **EnvironmentAlert:IntrusionAlert** | This is a sublcass of EnvironmentAlert | An intrusion alert is raised when a suspicious intrusion occurs in one of the facilities | Position, Facility |
| **EnvironmentAlert:UnsafeEnvironmentAlert** | This class is a sublcass of the EnvironmentAlert it models the a declaration of an unsafe environment | Sometimes a place or a facility can be declared unsafe for the staff to be in it or to be using it, in this case an unsafe environment alert is raised to declare this incident | Zone,  Degree |
| **EnvironmentAlert:FreezingAlert** | This is a subclass of the EnvironmentAlert. It models a freezing alert | A freezing alert occurs when the danger of freezing threatens a part of the network | Zone |
| **EnvironmentAlert:OverheaingAlert** | This is a subclass of the environment alert, it models an overheating alert | When a part of the network is exposed to high temperature exceeding the tolerable threshold an overheating alert is raised | Zone,  Temperature |
| **EnvironmentAlert:FloodingAlert** | This is a subclass of the environment alert, it models a flooding alert | When a flood occurs, a flooding alert is raised | Zone,  WaterLevel |
| **Alert:LeakAlert** | A subclass of the Alert class, it models a leak alert | This happens when the network suffers from a leak | Zone |
| **Alert:MalfunctionAlert** | This is a subclass of the Alert Class, it models a generic malfunction alert | A malfunction occurs when a device breaks down or when an electric disrupt occurs.  When this happens, a malfunction alert should be raised | ConcernedDevice |
| **MalfunctionAlert:DeviceBreakdownAlert** | This is a subclass of the MalfunctionAlert, it models a device breaking down | When a device is broken down this type of alert should be raised |  |
| **MalfunctionAlert: ElectricDisruptAlert** | This is a subclass of the malfunctionAlert, it models an electric disrupt alert | This alert is raised when the power supply to a device or a facility is disrupted |  |
| **Alert:WaterAlert** |  |  |  |
| **WaterAlert:FlowAlert** | This class is a subclass of the WaterAlertClass it models a flowAlert | A flowAlert can be raised when the water flow is too low or too high | HighThreshold, LowThreshold,  Trigger |
| **WaterAlert:PressureAlert** | This class is a subclass of the WaterAlertClass it models a pressure Alert | A pressureAlert is raised when the water pressure is too low or too high | HighThreshold, LowThreshold,  Trigger |
| **WaterAlert:WaterQualityAlert** | This class is a subclass of the WaterAlertClass it models a A WaterQuality Alert | When the water quality does not meet the predefined norms, this alert is raised |  |

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| **Claim** | Generic class for claims raised either by the water utility or the users | Allowing to model claims | ClaimDate,  ClaimAuthor,  ClaimResponse,  ClaimSubject |
| **Claim:OverConsumption** | A specific claim of overconsumption claim | Allowing to model a claim of overconsumption raised either by the user who claims that the amount charged by the water provider is overestimated or it can also be raised by the water provider in case the client waste too much water | Period,  Amount |
| **Claim:WaterShortage** | A specific claim of water shortage | Allows the client to claim that her water supply has been suffering from a water shortage | Period,  IsFixed |
| **Claim:PoorWaterQuality** | A specific claim concerning a poor water quality | Allows the client to claim that the water quality is poor | Period,  IsFixed,  HasSample,  Observations |

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| **Intervention** | This class models a generic intervention undertaken by the staff on the water network | An intervention can be to install a new equipment, conduct a measurement, renew a consumable, or renew a device | Date,  Cause,  Responsible,  Site,  Cost |
| **Intervention:Installation** | This is a subclass of the intervention class, it models an installation of a new equipment |  | InstalledEquipment |
| **Intervention:ConsumableRenewal** | This class is a subclass of the intervention class, it models, an intervention to renew a consumable | Some consumable in the network may be used up or may reach their expiry date, in this case a renewal intervention should be conducted | Consumable,  Expiry date |
| **Intervention:Measure** | This class is a subclass of the intervention class, it models, an intervention to conduct a measurement | Sometimes the measurement sent by a sensor needs to be verified by another measurement conducted on the site by one of the staff. This intervention is called a measurement intervention | Measurement |
| **Intevention:Renewal** | This class is a subclass of the intervention class, it models an intervention to renew a device | Devices may be required because of an upgrade or may wear up and require to be renewed | InstalledDevice |

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| --- | --- | --- | --- |
| **Measurement** | Is the act of carrying out a measurement procedure to estimate a value for a property | Models a generic act of measuring | MadeBy (Sensor),  Procedure,  MeasuredProperty,  OriginatedBy,  HasAResult,  MeasurementFrequency,  ResultTime |
| **Measurement:NoiseMeasurement** | A measurement of noise at at a given place in the network | A relative increase in the noise measured in the network) may be used to detect if there is a leak in the system (since the leak). Thus a comparative analysis of noise in terms of a noise "average" to determine or locate a leak | AverageNoise,  Type,  NoiseUnit |
| **Measurement:TemperatureMeasure** | Measures the temperature at a given place in the network | Monitoring the temperature is vital to assess the conditions of the networks and the quality of the distributed water. Temperature should be measured in pipelines, reservoirs, etc. | AcceptableTemperatrueValues,  AverageTemperature,  TemperatureUnit |
| **Measurement:WaterMeasure** | This class represent a generic water measurement | The purpose is to measure the flow, the pressure, or the volume | Type, |
| **WaterMeasure:FlowMeasure** | This class represents a measurement of conducted to measure the water flow (m3/sec) at a given position in the pipelines or in a reservoir | Ensuring a minimum water flow is vital to ensure a comfortable distribution for users. On the other hand high flow is harmful for the network.For this reason flowrate measurement should be conducted | FlowRateUnit,  AcceptableRange,  AverageFlowRate |
| **WaterMeasure:PressureMeasure** | This class represents a measurement of conducted to measure the water pressure (typically measured in bars) at a given position in the network | Typically, a minimum pressure is imposed. A comfortable pressure for the user is 3 bars. For this reason the pressure should be measured at different places on the network | PressureUnit,  AcceptableRange,  AveragePressure |
| **WaterMeasure:VolumeMeasure** | This class represents a measurement of conducted water to measure the water volume (typically measured in M3) | Monitoring the volume of water traversing each sector allows to detect leaks, hence the need of volume measurements | VolumeUnit |
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## 6 APPENDIX : List of WATERM classes and their hierarchy

Here we provide the list of WaterM classes and their hierarchy.

* Client
  + Collectivity
  + DomesticClient
  + IndustrialClient
* Device
  + Electric Device
    - Data Center
    - Fan
    - Generator
    - Pump
    - Actuator
      * OnOffRelay
    - Sensor
      * Environment Sensor
        + AirSensor
        + DeviceThermometer
        + OverflowSensor
        + PresenceSensor
        + State Sensor
      * LevelMeter
      * Sonometer
      * Thermometer
        + DeviceThermometer
        + WaterThermometer
      * WaterSensor
        + Flowmeter
        + Manometer
        + Meter
        + WaterQualitySensor
        + ImpulseMeter
        + PressureMeter
      * Photosensor
      * Humidity
      * LightLevel
  + Tank
  + Water Device
    - Bladder
    - Controller
      * FlowLimiter
      * PressureLimiter
      * PumpingGroup
        + Accelerator
        + Booster
        + PumpingStation
    - FireHydrant
    - Pipe
    - Reservoir
      * Basin
      * WaterTower
    - Sector
      * PrivateSector
      * PublicSector
    - Valve
* Incident
  + //Alert
    - EnvironmentAlert
      * IntrusionAlert
      * UnSafeEnvironmentAlert
      * FreezingAlert
      * OverheatingAlert
      * FloodingAlert
    - LeakAlert
    - MalfunctionAlert
      * DeviceBreakdownAlert
      * ElectricDisruptAlert
    - WaterAlert
      * FlowAlert
      * WaterAlert
      * PressureAlert
      * WaterQualityAlert
  + Claim
    - OverConsumption
    - WaterShortage
    - PoorWaterQuality
* Intervention
  + ConsumableRenewal
  + Installation
  + Measure
  + Replacement
* Measurement
  + NoiseMeasure
  + TemperatureMeasure
  + WaterMeasure
    - FlowMeasure
    - PressureMeasure
    - VolumeMeasure
* MeasureUnit
  + EnergyUnit
  + FlowUnit
  + NoiseUnit
  + PressureUnit
  + TemperatureUnit
  + VolumeUnit
* Staff
  + Manager

## 7 Configuration

Configuration is to define how to communicate with software component and data model.

Admin configuration is must be different than user configuration

Configuration table can be used in xml files and readable configure parameters such as;

User id –Specifies the user defined in database

Password-Specifies the password credentials for accesing the database

Connection string –Including machine name(ip number) ,user id,user password,database name

Database name –Database name which storing the measurement data

Database type – According to database type connection string can be changed,specifies the which database used for local or Global data

Gateway – Provides communication with other subnet defined in water-m platform.

7.1 Configuration Manager

Configuraiton manager is GUI (Graphical user interface) that provide configuring the administration purposes.This application manages the configuration parameters in order to communicate with local or global databases.

Functions;

* Provide confidential and authenticated access
* Establish confidential connection with Local and Global side
* Allow or Deny to perform necessary operations