ITEA 2
INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

D2.1 Functional and Technical Architecture

WATER-M

Unified Intelligent WATER

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1.3	06/03/2017	Ali KAFALI	API definition

INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

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I. Acronyms and Definitions

Table 1: Acronyms and Definitions

TERMS	Definitions
6lowPAN	IPv6 Low power Personal Area Network
AAA	Authentication, Authorization and Accounting
CA/RA	Registration Authority/ Certificate Authority
CE	Collection Engine
CEP	Complex Event Processing
CoAP	Constrained Application Protocol
DA	Data Automation
DHCP	Dynamic Host Control Protocol
DNS	Domain Name System
DODAG	Destination Oriented Direct Acyclic Graph
ETL	Extract Transform Load
FAR	Field Area Router
GIS	Geographic Information System
HAN	Heterogeneous Network
IEEE	Institute of Electrical and Electronics Engineering
LLN	Low power and Lossy Networks
NAN	Neighbourhood Area Network
NMS	Network Management System
NTP	Network Time Protocol
PAN	Personal Area Network
PUBSUB	Publish Subscribe
RF	Radio Frequency
RTU	Remote Telemetry Unit
WAN	Wide Area Network

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1. Introduction

1.1. Purpose

The purpose of this document is to formally provide the overall architecture of the WATER-M platform, that will unify the technical and the functional specification, taking into account the requirements as recognised in the task T1.4 and T1.5. This document explains the detailed information about the functional building blocks and their sub-blocks comprising the whole architecture, how they interact with one another to fulfill each requirement, definition of the appropriate networking scenarios and a coarse description of the hardware and software characteristics of the different units. The architecture will layout the main functional groups and components and provide a blue-print for the implementation of concrete modules.

1.2. System Overview

The system architecture of the WATER-M unifies the technical and the functional specification and ensure that the data and the control flows are adequate and the integration of the each sub-systems run smoothly during the implementation. This architecture is based on an open standards in order to obtain the interoperability. It is robust, scalable and flexible to adapt with the changes necessary in the future so as to remain successful in the market. In general, this system architecture supports various functionalities as integrated real time data and off the self services platform for the distributed water grid network, support the data processing mechanisms and the algorithms to enable the real time decison making and dsitrubuted control. In addition, the reliability and security are also taken into consideration in this architecture. Integrity, Confidentiality, authentication, authorization, accounting are the aspects of security whereas reliability covers the guaranteed delivery of the messages, detection and elimination of the duplicates etc.

1.3. Architecture Elements

According to UC’s requirements list written below;

1.3.1. Measurement Data

Water-m platform needs measurement data for monitoring,alarms and event data thus row data must be captured from the sensors ,smart meters, actuators and plc.

1.3.2. Resources

Resources produce digital data from the row data sources like heat,pressure,flow meters.

1.3.3. Sensors

Sensors ,smart meters or plcs aims to send desired data in to the water-m platforms.

1.3.4. Gateways

Provides connection with the internet sources.

1.3.5. Real Time Platform

Provides the real time communication middleware, the real time services and the CEP engines.

The Real Time Platform contains the different technological elements that provides real time processing and transaction features as a real time Publish/Subscribe middleware implementation, based on the DDS Standard, a CEP engine to correlate the events and rules patterns and orchestration services.

1.3.6. Data Model

An integration platform needs a unified message model,the message oriented middleware defines the data structures and models that can be interchange between elements, systems, etc.

2. System Requirements

- Security
- Performance
- Scalability
- Reliability

3. Water-M Use Case Functional Description

Use case No	Precondition and Assumption	Resources	Country	Partners
1-Leak Detection	1-Localisation of the sensors nodes; 2-Sensors must be online and make (have the) definition of the sensors location on the network; 2-Sensors attached telecommunication devices; 3-Pressure sensors need power; 4-Software implementation;	Sensors, PLC, Communication Devices	TR	ACD MANTIS
2-Development of Water Management and Flood Risk Prevention Platform	1-The sensors are installed on the field. 2-The sensors are connected to the 3-Remote telemetryunit (RTU) by wire. 4-The connection between Sensors and Gateway must be established. 5-Gateway is connected with Data Presentation Server through the Internet.	Sensors, RTUs, Gateway, Special Application server, Central server.	RO	BEIA
3-River Telemonitoring	1-The sensors are installed on the field. 2-The sensors are connected to the 3-Remote telemetryunit (RTU) bywire. 4-TheconnectionbetweenSensors andGatewaymustbeestablished.	1-Water temperature and level probe sensors; 2-RTUs: 3-Gateway; 4-Data presentation server.	RO	BEIA
4-Performance monitoring of water distribution Network	Sensor measurement available, Network connection	1-Sensor data from the water network (at least flow, pressure and volume); 2-Information about the network	FR	City of Saint-Etienne, Telecom Saint Etienne, Stéphanoise des eaux/Suez,

		(geolocation and characteristics of the water devices);		Itron
5- Control and optimisation of the water distribution network	Sensor measurement available, Network connection, access to the data, Rules defined by the water provider for event detection and control actions	1-Sensor data from the water network 2-Information about the network (geolocation and characteristics of the water devices) 3-IT network for sensor exchange 4-Data analyses services 5-Complex event processing for event detection based on the rules provided by the water provider 6-Authentication mechanisms, which may selectively or fully provide access to the data for a given user 7-Mechanisms to send the commands to the actuators 8-Low latency control loops	FR	City of Saint-Etienne, Telecom Saint Etienne, Stéphanoise des eaux/Suez
6-Coordinated management of networks and sanitation structures, improving and securing the operation of sanitation facilities, “real time" knowledge of volumetric flow.	1- Water treatment plant has sensors and Plc devices for controlling the parameters defined in the system. 2- Define control parameters upper and lower limits. 3- Accessing sensors and controller Plc devices by reading relevant protocols and data. 4- Real time measurement data must be recorded by date time and value. 5- Action plan must be defined in the system (authorized	Sensors, Plc, Pump and motor connection.	TR	ACD MANTIS

	person phone number, email etc.). 6- Sensors location, Plc location, pumps location and id number created. 7- Sensors calibration. Network audit.			
7-New Redox Monitoring	1. Water intake line has selected quality parameter units monitoring water quality in 30 minutes intervals 2. Defined upper and lower limits 3. Protocols to data transfer and data storage 4. Warning protocol if changes are monitored	Sensor, Data transfer system, water side stream/in-line instalments Software: Wireless communication, Data analysis programs	FIN	University of OULU, Kajaani University of Applied Sciences (prev. Measurepolis), THL, Savonia, EHP Tekniikka

4. Water-M IoT Platform Architecture

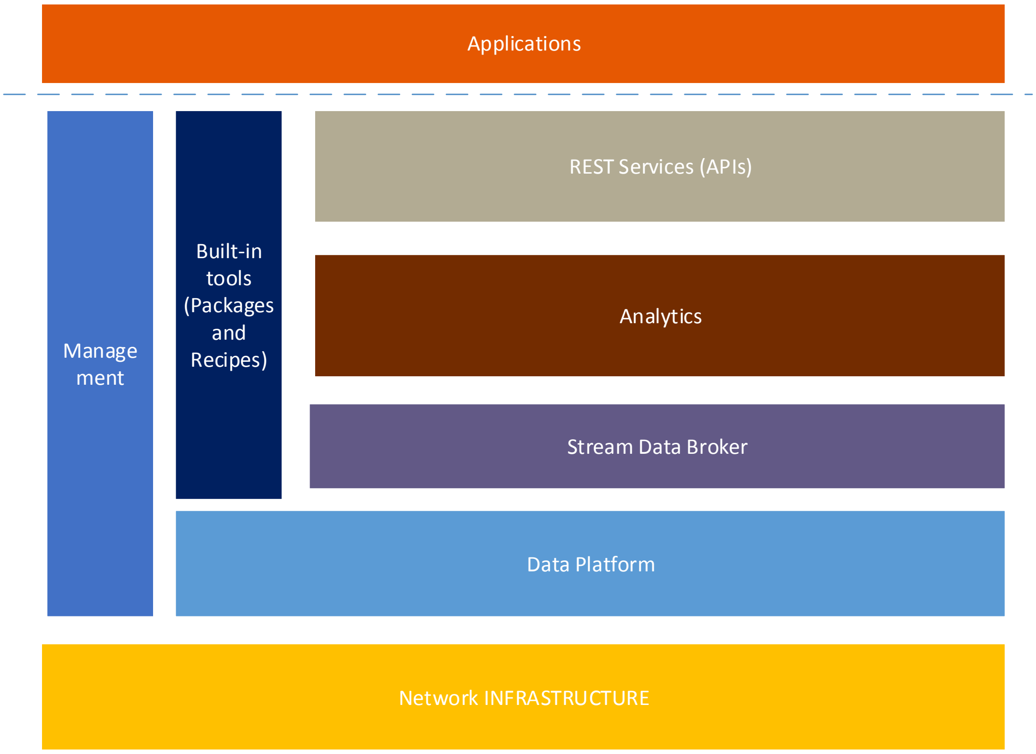

Figure 1: Water-M IoT Platform Architecture

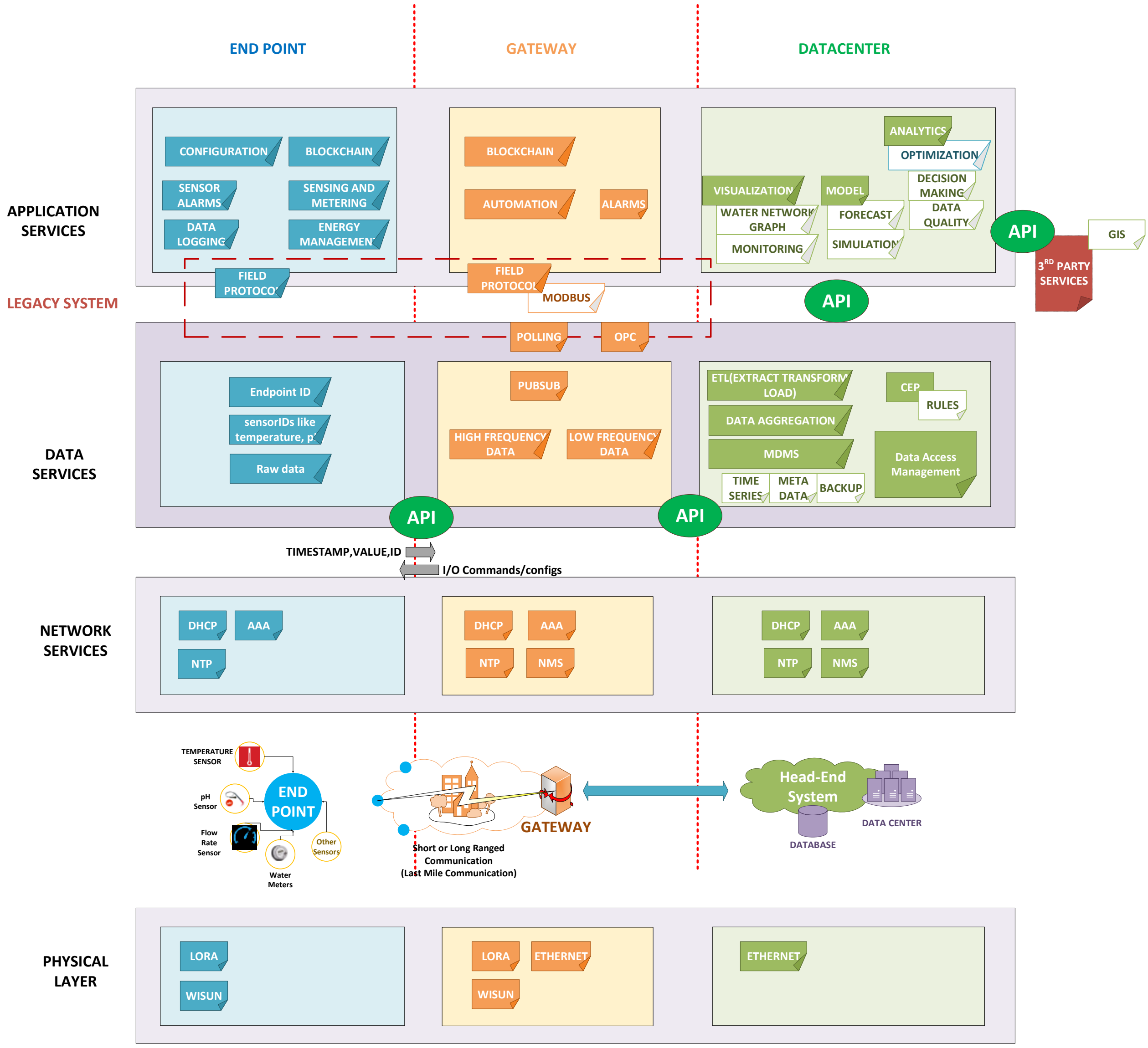

Figure 2: Water-M Detailed System Architecture

4.1. ROLES of various elements in the architecture

4.1.1. END SERVICES

There are various end services provided by the Water-M platform to support various use cases as explained D1.7 Use case conceptual framework. They are:

- Leak Detection
- Over Pressure Detection

- Water quality (pH, turbidity)
- Smart farming
- Waste Water Treatment

4.1.2. LEGACY SERVICES

The framework should be able to deal with legacy systems:

- Either to replace them: in such as case the new system should be able to integrate historical data from the older systems
- Or to keep them as is: for various reasons, the already existing devices can be kept and their data retrieved through any available mean. Usual examples are Modbus data acquisition for instance, or queries over OPC services in SCADA systems.

4.1.3. APPLICATION SERVICES

The following explains the various services provided at the application layer at the various parts of the network.

A. End Points:

i. **Configuration**
Several application configurations are kept in the end point such as: data transmit interval.

ii. **Sensing and Metering**
This module senses the various sensors connected with the node such as pH sensor, temperature sensor, flow rate sensor, pressure sensor etc along with the metering data information.

iii. **Data logging**
Data logging logs/stores some data/information locally at the end point.

iv. **Sensor alarms**
This module detects/sets various alarms and communicate them to the HES via gateway. There may be some intelligence build at the end point in order to take the necessary actions.

v. **Energy management**
This module controls the internal energy use of the hardware.

B. Gateway

i. **Automation**
This is an intelligent module that helps to automate various tasks, based on control signals. Upon receiving data/information from the nodes, the gateway can forward it to the cloud or can take necessary actions locally as well. A typical scenario would be a control loop of an industrial equipment.

ii. **Alarms**:
Local alarm managment.

C. Cloud or HES

i. **Analytics:**

The Application of Smart Water Analytics is to identify patterns and problems in the complete water provision and circulation life cycle and differentiate between issues such as excessive use of water and any possible leakage of water which could result in the waste of millions of gallons of water. It also provides water utilities with accurate insight in identifying when low or no water use signals a problem. This will effectively reduce the number of false alerts which further helps technicians know most optimal schedule when meters need replacement or repair.

a. Optimization providing more effective and efficient management of drinking water through the targeted use of big data and advanced analytics.

ii. **Decison making**

It helps the users to act to make various smart decisons depening on various factors or variables.

iii. Data Quality:

Validate the quality of data before being used for analytics. The data quality can be evaluated based on timestamp, location, source and security process.

iv. Modeling

a. Simulation: simulate the components of the water network distribution.
b. Forecast: predictive algorithms help water management companies and utilities better plan for demand and as a result, have better manage resources, such as pump scheduling, tank levels, and pressure.

v. Visualization

This module shows the result in a graphical way in order to monitor the network, its topology. It consists of following sub-modules

a. Water Network Graph
   This graph shows the logical network topology regarding the link conditions
b. GIS
   This module gives the geographic location the nodes. Currently, we obtain this information via API.
c. Monitoring
   Various monitoring tools such as graphs, charts etc are used to monitor the results.

4.1.4. DATA SERVICES

These are the services provided at the data layer.

A. End Points:

i. **ID**

Each end point needs to have a unique identifier.

ii. **SensorIDs:**

Each sensor has different definition and Sensorid.Scada systems which are already established in the water plant may have different protocol definition and its own tag definition that must be integrated with the water m platform.

B. Gateway

i. **PUBSUB**

Pubsub (Publish subscribe) mechanisms enable the data to be dispatched as soon as they are available (as an alternative to polling information)

ii. **High Frequency Data** (data from water pumps, turbines)

Some application scenarii may require high frequency data to be processed, especially when control loops or reactive demand make sense.

iii. **Low Frequency Data**(data from sensors, meters)
Depending on the requirements, such data could be:
- Sampled at a regular interval, from every 10 minutes to everyday.
- Send to the cloud for storage, from every hour to every month.

C. Cloud

i. **ETL(Extract transform Load)**
The data format and content may require a transformation step before it can be, for instance:
- Enrichment : from the ID of the device, reconstruct some additional information (e.g. the area in which the sensor is located) for further analysis
- Merge/split : one could merge (e.g. data fusion) or split (e.g. reconstruction of intraday patterns from low frequency sensors) some information from various end points
- Format adaptation : each sensor may have its own internal semantics, therefore a pre-processing step is required to be understood by analytic applications
- Load : data can be stored or put in-memory for quick data access

Some data quality analysis and alerts may also be generated at this step.

ii. **Data Aggregation**
Raw data from sensors or meters may in some cases be delivered over a high frequency which is not required for longer term application scenarii. For instance, one may measure raw data every second, send them to the gateway every hour and store it on the cloud every day.
Data aggregates could also be related to geographical or area queries for instance, in case the system provides a GIS query mechanism.
One could also generate other derived data, such as benchmarks.

iii. **Data Backup**
Backup requirements may be linked to operational or legal needs. For billing purposes a company may be required to keep the records and be able to load them over a period of 5 to 10 years for instance.
Backup and audit should be aligned with IT security principles, to make sure data can be recovered even after a disaster (total loss of power, hardware failure etc).

iv. **Complex Event Processing (CEP)**
The goal of complex event processing (CEP) is to combine data from multiple sources to infer patterns and identify meaningful events and respond to them.

a. Rules
The CEP is designed to support an expressive language for rule definition while offering efficient processing mechanisms.

b. Handling uncertainty in measurements
A specific requirement in our use case is that data measurement have a confidence interval, so rules and alerts should be able to manage those requirements.

v. **Time Series**
Sensors or meters typically deliver timestamped values, which may be stored and later use for historical or predictive analysis.

vi. **Meta Data**

Meta data are useful to provide information on what is represented by the time series. Standard operations would include the search based on criteria such as:

- Select
- Range
- Where
- Group-by
- Order-by
- Etc…

Example:

```
{
"select": "consumption",
"where": {
"region": [ "europe", "us-east" ]
    },
"range": {
"from": "20160102T123000.000000",
"to":   "20160102T123010.000000" }
}
```

Depending on the actual implementation, those queries could be managed via SQL or any other database mechanism.

Another type of metadata is linked to the relationship between the different sub-systems or assets, which can be expressed through a graph topology. For instance, the water network can be sub-divided in different sub-networks, themselves composed of equipment which may embed sensors.

vii. **Data Access Management**

Users should have access only to the data they require. Administrative access should be limited as much as possible.

D. APIs

Defines the functionality of the middleware that supports and a communication protocol that should serve the middleware so that implementations from different manufacturers can interoperate with each other. It is a model that operates under the publish/subscribe paradigm, based on data-centric criteria and based on the criteria of quality of service ar both supported.

Blockchain / transactions / billing

4.1.5. NETWORK LAYER SERVICES

These are the services provided at the network layer in order create and maintain a link between the various elements ensuring the reliability, security etc.

A. End Points:

a. DHCP

DNS provides the name resolution for the nodes that is assigned to an IP address whereas DHCP is responsible for providing the addresses to the nodes dynamically and transparently. DHCP servers are responsible for providing a unique addresses to its clients. The endpoints need to have a DHCP client.

b. AAA

This entity is responsible for the Authentication, Authorization and Accounting of the various nodes in the network and is very critical for effective network management and security issues. It interacts with the network and gateway servers and with the directories containing the user/node information. Authentication is the process of identifying a particular node or a user in a network with their unique id. Authorization is the method to authorize or to grant/deny the access to the nodes and Accounting is to keep track of the activities of the nodes such as: time spent in the network, amount of data transferred which can be used for analysis, billing and other purposes. RA/CA are the Registration authority and Certificate Authority Server.

c. **NMS**:

Network management Services Detect, Diagnose, & Resolve Network Issues Before Users Know There's a Problem. An NMS client version is embedded in endpoints.

d. **NTP**:

Network Time Protocol (NTP) is a networking protocol for clock synchronization between computer systems over packet-switched, variable-latency data networks.
It provideds the network time for the end points.

B. Gateway (same as above)

C. Cloud or HES

a. CE (Collection Engine)

It is responsible for collecting the metering data all the way from the sensors/ meters and some control data back to them. It is also responsible for registering the meters to the network. It is capable of sending both multicast and unicast request to the meters.

5. End to End Network Infrastructure Architecture

The following architecture shows the general end to end connection for transport of the data/ information from the home to the head end system.It explains the various components and their sub-components that comprises this architecture and describes how they interact with one another to provide the end-to-end communication. Figure 3 shows the general network architecture in a high level whereas **Erreur ! Source du renvoi introuvable.** depicts the same in a detailed manner.

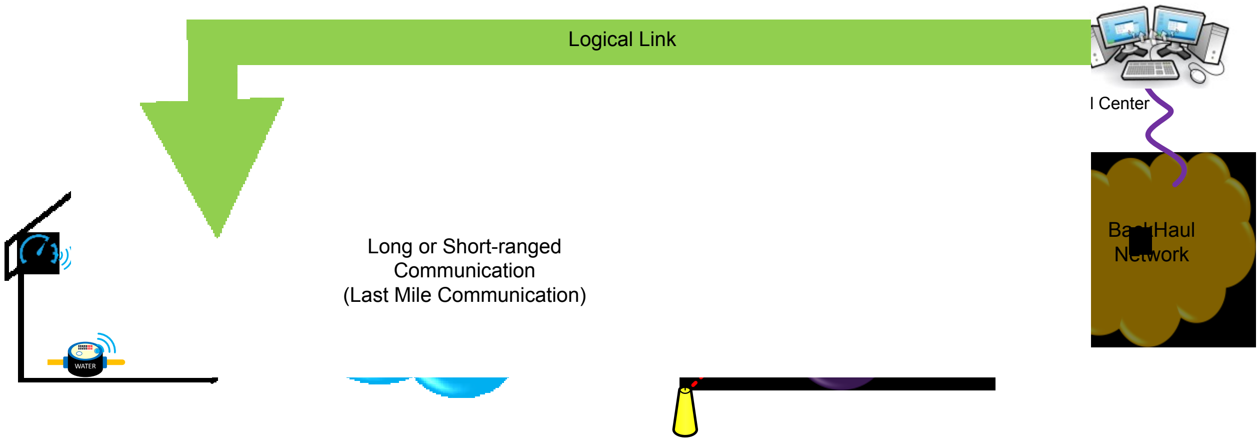

Figure 3: High level End to End System Architecture

The whole network architecture of WATER-M can be classified into four distinctive network areas or segments:

a. HAN (Home Area Network)
b. NAN (Neighbourhood Area Network)
c. WAN (Wide Area Network)
d. Backhaul Network

5.1. HAN (Home Area Network)

The communication method used for this part of the network may be wired or wireless. For the WATER-M architecture, HAN is a small network that is formed inside the home premises providing the interaction between various elements such as the water meter, water quality sensors (such as pH sensors, leak detection sensors, turbidity sensors, flow rate sensors, pressure sensors etc.), home level gateway which may or may not be an electric meter and other smart objects. The sensors do the necessary measurement about the quality of the water and the water meter measures the water consumption and transmit the data to the home level gateway. The home level gateway acts as an interface between the HAN and the NAN and is responsible for collecting the data and information and then send it to the data concentrator in a single or multi hop fashion.

5.2. NAN (Neighbourhood Area Network)

NAN solution is responsible for transmission of the data from meters/home level gateway from various homes to the data concentrator in a single or multi hop manner in a secured way. And, also some control signals back to these HAN elements from the HES. The communication technology used for this part is the RF and is based on the open standards in every layer of the protocol stack (Section

Erreur ! Source du renvoi introuvable.) to achieve the interoperability. It is composed of several PANs (Personal Area Network) which is rooted to a FAR (Field Area Router). Each FAR acts as a PAN co-ordinator and a DODAG (Destination Oriented Directed Acyclic Graph) Root.

5.3. WAN (Wide Area Network)

The gateway in the WAN is responsible for sending the metering and the sensor data from the data concentrator location at different areas and then provide them to the HES via the back haul network through the use of the internet.