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D8.3– Integrated sensors platform design

Project Information

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Contributors	-
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Dissemination Level

PU	Public	
PP	Restricted to other program participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for the members of the consortium (incl. Commission Services)	☒

Document Log

Version	Date	Author	Description of Change
V1.0	20/03/2022	Evangelos Angelopoulos	First draft

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V2.0	30/03/2022	Evangelos Angelopoulos	Final Document
V2.1	31/03/2022	Andreas Sapalidis	Final Review

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1 Executive Summary

This document refers to the deliverable D8.3 "Integrated sensors platform design". It describes a new technology stack developed by Fuelics PC that solves the problem of the integration of multi- disciplinary, multi-protocol, of-the-self sensors that will be acquired to measure various different physical parameters in all three lab and the real life pilots of Intelwatt.

The technology described is a generic way to connect any type of commercial available products to a aggregating point in order to retrieve their data if they are sensors or guide them to execute if they are actuators.

This report is confidential. The IP described belongs to Fuelics but will be used for R&D purposes for Intelwatt project with the aim to unify the sensors signals towards the cloud.

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2 Introduction – The problem

This document supports and adheres to D2.3 “Report on sensor requirements”, D8.1 "Report on sensors" and D8.7 “Sensor data ingestion System”.

Intelwatt projects connects two worlds, that of membrane scientists and data scientists. Both worlds have one common goal, that of cooperation so that data stemming from the membrane apparatuses can become available for data scientists. Once available, the latter scientific world will model them in order to train an AI model that will eventually provide suggestions on how to better control and actuate physical properties of the membranes in order to better meet the various KPIs of the project.

In order to receive physical data, sensors are being used. In intelwatt the sensors are either off-the-self or custom made. Both type of sensors have a measuring capability and a connection interface so that they are able to relay the measured information.

Sensors features

As reported in D8.2 off-the-self sensors come in various shapes with various out protocols. In the following table we will include commercially available sensors and their output in order to highlight the wealth of solutions being offered to the scientific community. In all the cases the output characteristics of the sensors are:

- 4-20mA
- 0-5V or 0-10V
- RS485
- Protocol

Name	Communication protocols (output)	Name	Communication protocols (output)
EXO 1 Multiparametric probe 	**Rs-485, Rs - 232, Modbus, Sdi-12**	Calcium Ion Electrode 	**4-20 mA**

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Name	Communication protocols (output)	Name	Communication protocols (output)
Calcium ion sensor 	4-20 mA	Sulphate sensor 	Analog 4 - 20 mA max. 500 Ohm load, standard 1, max. 8 (option) Optional digital output:RS232, Modbus(TCP/IP , RS485)
Name	Communication protocols (output)	Name	Communication protocols (output)
Density Sensor 	Analog output 4-20 mA Digital I/O USB, RS232, and RS485 (2-WIRE) protocols	Silicon Solar Radiation Sensor 	Outputs 0-160mV; 4-20mA; 0-1V; 0-2V; 0-5V; RS485; Modbus
Name	Communication protocols (output)	Name	Communication protocols (output)
Pressure Sensor 	4-20 mA or 0-10 V	Vortex Flow Meter 	4-20mA
Name	Communication protocols (output)	Name	Communication protocols (output)
Copper and Nickel Sensor 	4-20 mA		4-20 mA (?)

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3 The Solution – A new Technology Stack based on 802.15.4

It is evident that commercial sensors have different outputs. This is a main problem that led Fuelics in thinking out of the box in order to solve this problem among other few that are being met within industrial environment such as:

- Low or zero bandwidth cellular connectivity (3G, NBIoT, GPRS)
- High Electromagnetic noise
- Big incremental distances
- Concrete reinforced walls
- Underground installations
- Zero remote management (local or over internet) capabilities, since commercial sensors are monolithic with no edge computing capabilities and pre-controlled way of functioning that cannot be altered
- Variety of sensor sizes (physical)

For all the aforementioned reasons we introduce a new technology stack that significantly differs from the existing technology stack based on Low Power Wide Area Networks (primarily Narrow Band Internet of Things) that we excel. The difference for our current technology is that the asset being monitored requires a direct communication based on a SIM card, either over NBIoT or the legacy GSM/GPRS. This is unpractical for research installations or even impossible. The technology was not included in the initial intelwatt proposal but was designed after conferring with partners and mainly the coordination team in Demokritos Premises.

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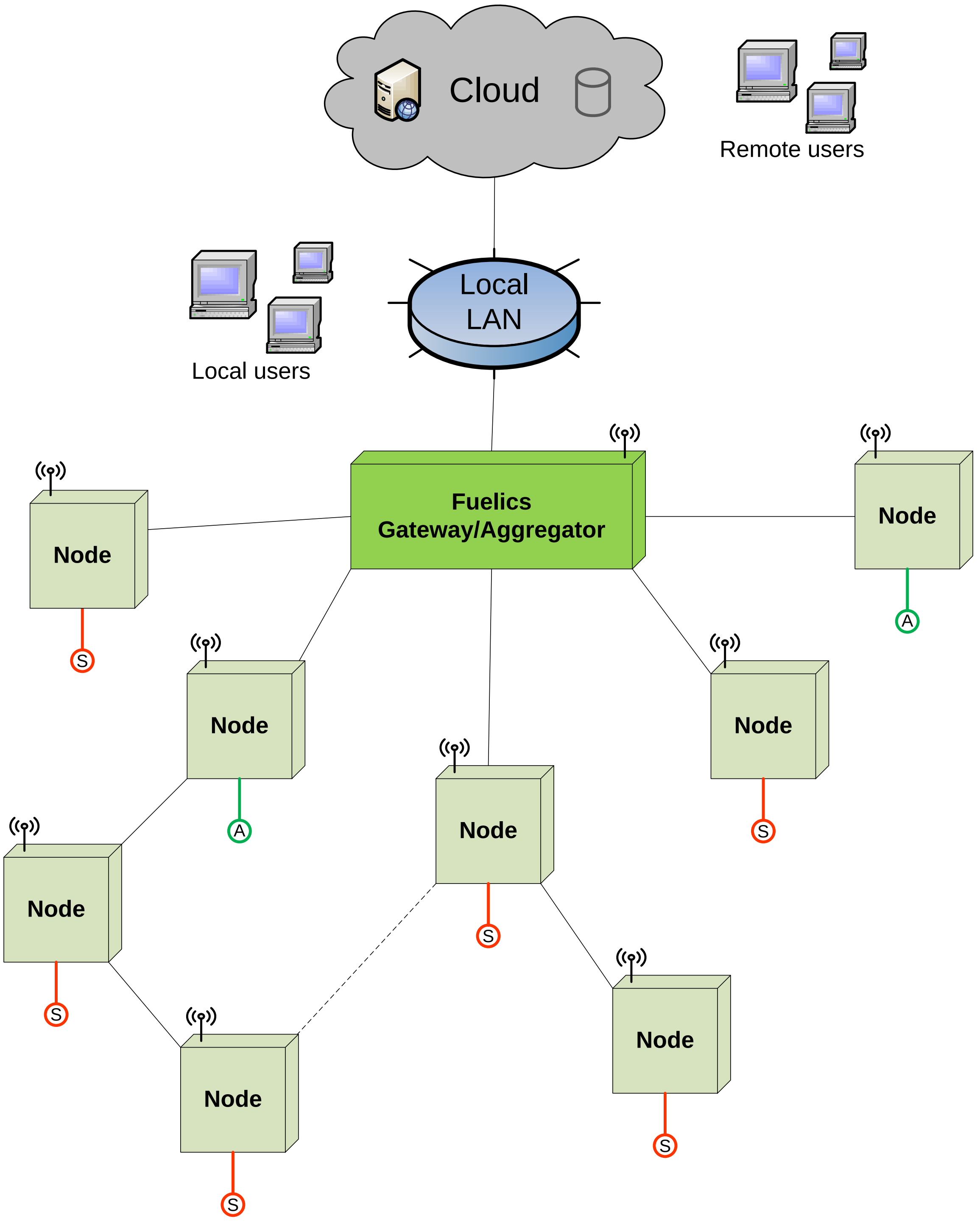
Architecture



The basic architecture of the proposed technology is based on 802.15.4 standard (https://en.wikipedia.org/wiki/IEEE_802.15.4) which is the basis of various wireless products around the globe. The main characteristics is the free protocol stack and the variety of frequencies of operation. In our case we will be using either the sub GHz band (800MHz) that allows distant connections or the 2.45GHz band that is perfect for confined installations, such as the lab environment.

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Any node can be simultaneously a sensor or an actuator. Any node can either directly connect to a central aggregation point (that is gateway connector) or through a mesh. This topology allows distant nodes to be able to relay information towards a gateway. The more the gateways the better the probability of relaying the signal towards the cloud. The more the nodes, additionally the better the possibility to relay the information, again, towards the cloud.

Terminology Introduced

F-UniSaG = Fuelics Unified Sensors & Actuators Gateway

F-SenCon = Fuelics Sensor Connector

F-ActCon = Fuelics Actuator Connector

RMS = Remote Management Server

FUS = Firmware Update Server

RM = Remote Management

FU = Firmware Update

Advantages of the technology introduced

- Introduction of sensors and actuators controlled by the same technology stack
- All modules (sensors and actuators) are controlled seamlessly from everywhere (local, internet, PC, Laptop, Mobile app)
- All modules are remote managed
- Ease of use (sensors can be easily replaced). Just change the sensor end
- Easy representation of sensor data (eg change 25 Celcius to 77 Fahrenheit)
- Complete control, intelligent management and automation of decisions (edge computing) based on criteria (eg when temp at 32 Celsius, turned on ventilation and send notification or alarm to a specific group)
- Machine learning algorithms on microcontroller level

This is the Network Architecture of the proposed technology stack. Each commercially available sensor or actuator will be **physically** connected to either a Sensor Collector module (***F-SenCon***) or an Actuator Connector module (***F-ActCon***) that will be using IEEE 802.15.4 wireless technology stack which is the technology basis of Zigbee, in order to transmit measurements or impose and actuation.

SensorConnector -ActuatorConnector

In principle, each module (sensor or actuator) can become a wireless node (a listener), therefore can act as a **meshed node** allowing data transmission of neighboring node. This way you need only one node to be connected to the agreggator in order to transmit information into the cloud. Below you can see a representation of an actual sensoring network where **S**ensor or **A**ctuating nodes are directly or indirectly connected to the aggregator which transmits in the local lan or the greater web.

The basic designing principles of the solution per node are put on the following diagrams for the Sensor and Actuating node. What is really important about the project is that either the input of the sensor or the output of the actuator supports:

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Analog Input or Output:

-4-20mA

-0-5 V

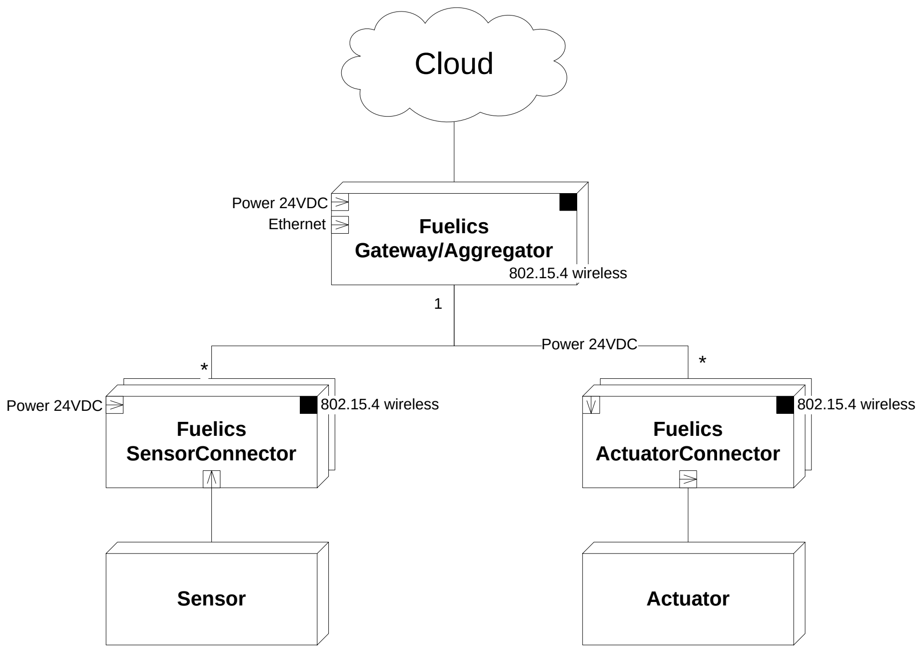
Digital Input or Output

Voltage (on/off)

Switch (on/off)

Whereas the default hardware connection is over UART which may extent the integration properties in the future based on the demand.

It is really important to mention that any output can be collected and any sensor's information can be relayed towards the aggregator, constituting this technology IDEAL for lab and industrial environments.



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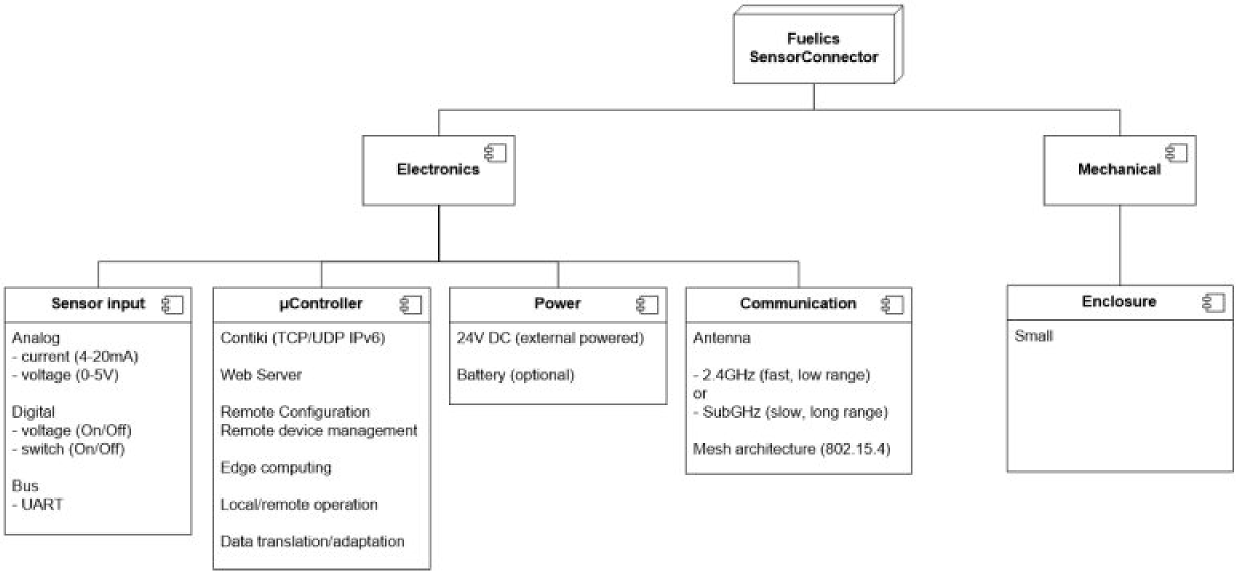

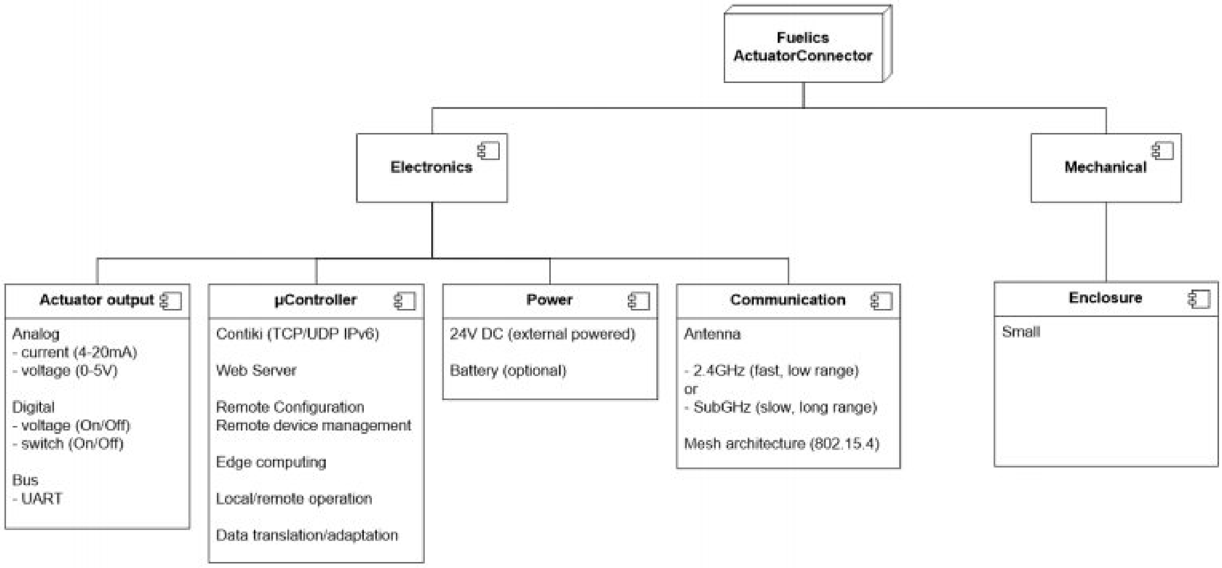

Fuelics R&D has prototyped so far the aggregator using the abovementioned analysis. We do estimate that within 2022 a full production cycle of sensorconnectors, actuatorconnectors and aggregators in the sub GHz and 2,45GHz band will be released and tested in Demokritos lab and then in the industrial demos.

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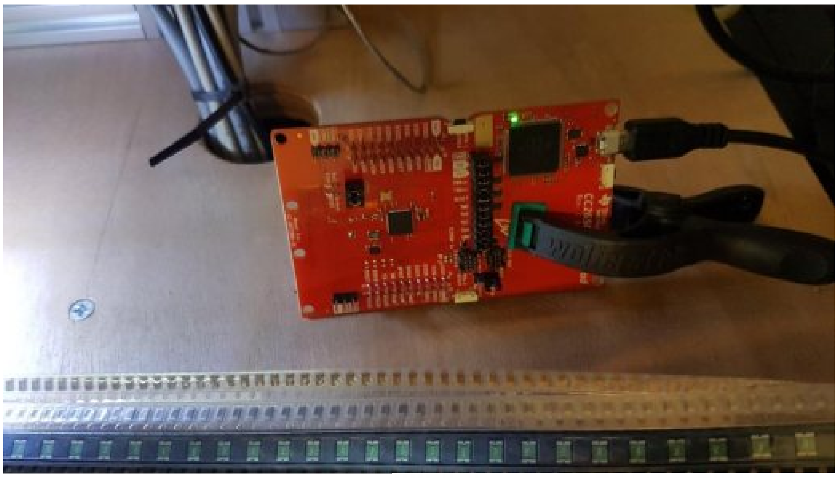
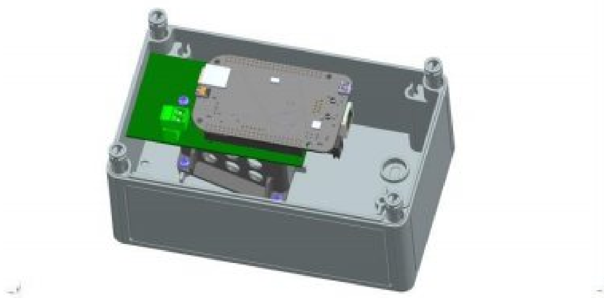
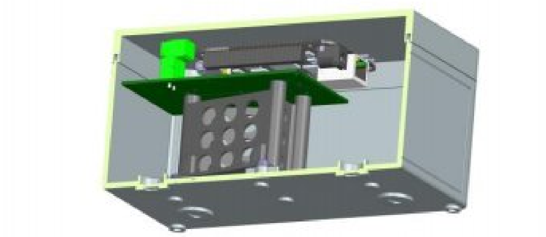
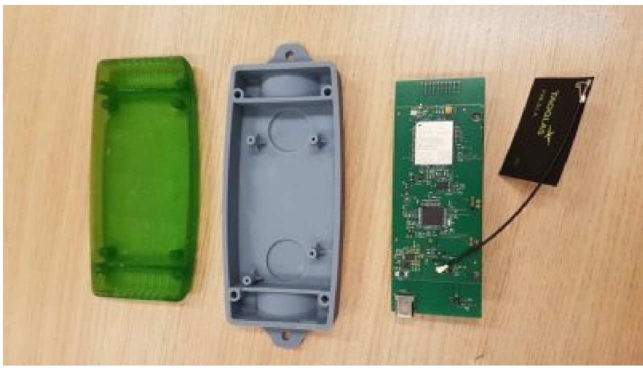
Herein we present a prototype on the 2.45GHz zone and the 3D printing designs that will constitute its casing. The prototype is based on a beaglebone and a casing developed in our labs.







Concerning the sub GHz band, we have a TRL9 product all ready presented herein.



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