Integrating the Cyber World with the Internet of Things: How to transform cities and industries into smarter places

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- Director of the MDSLab research group (mdslab.unime.it)
- Director of the CINI Italian Lab on Smart cities and communities https://www.consorzio-cini.it
- Responsible of the SmartME crowdfunding initiative to exploit Messina into a Smart city (smartme.unime.it)
- Co-founder of SmartMe (smartme.io)

STVDIORVM VNIVERSITAS MESSANAE

cini national lab Smart Cities & Communities

smartme.IO

consorzio interuniversitario nazionale per l'informatica

A consortium of 47 Italian Universities that:

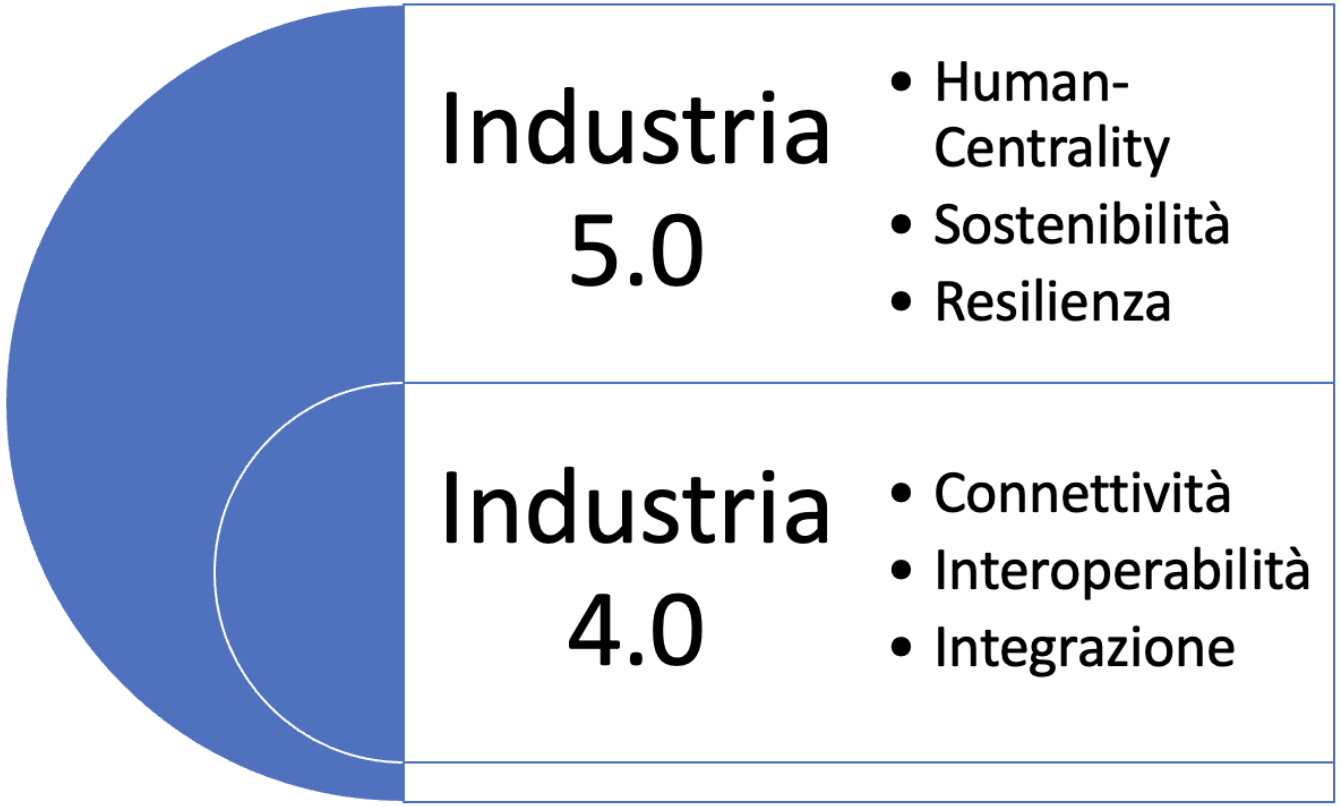
- do research in CS/CE
- deliver BS, MS, PhD degrees
- are public funded
- Involves 1,300+ professors of CS or CE

Goals

- Pave the way to promote and stimulate **projects of national dimension**
- Develop a reference platform to manage smart cities with an *open* approach for software, data and hardware
- Create ***Living Labs*** to facilitate the development of new services for the citizens and strength the cooperation with PA and industries
- Adopt ***re-using***, i.e. exchanging experiences and solutions among co-operating living labs

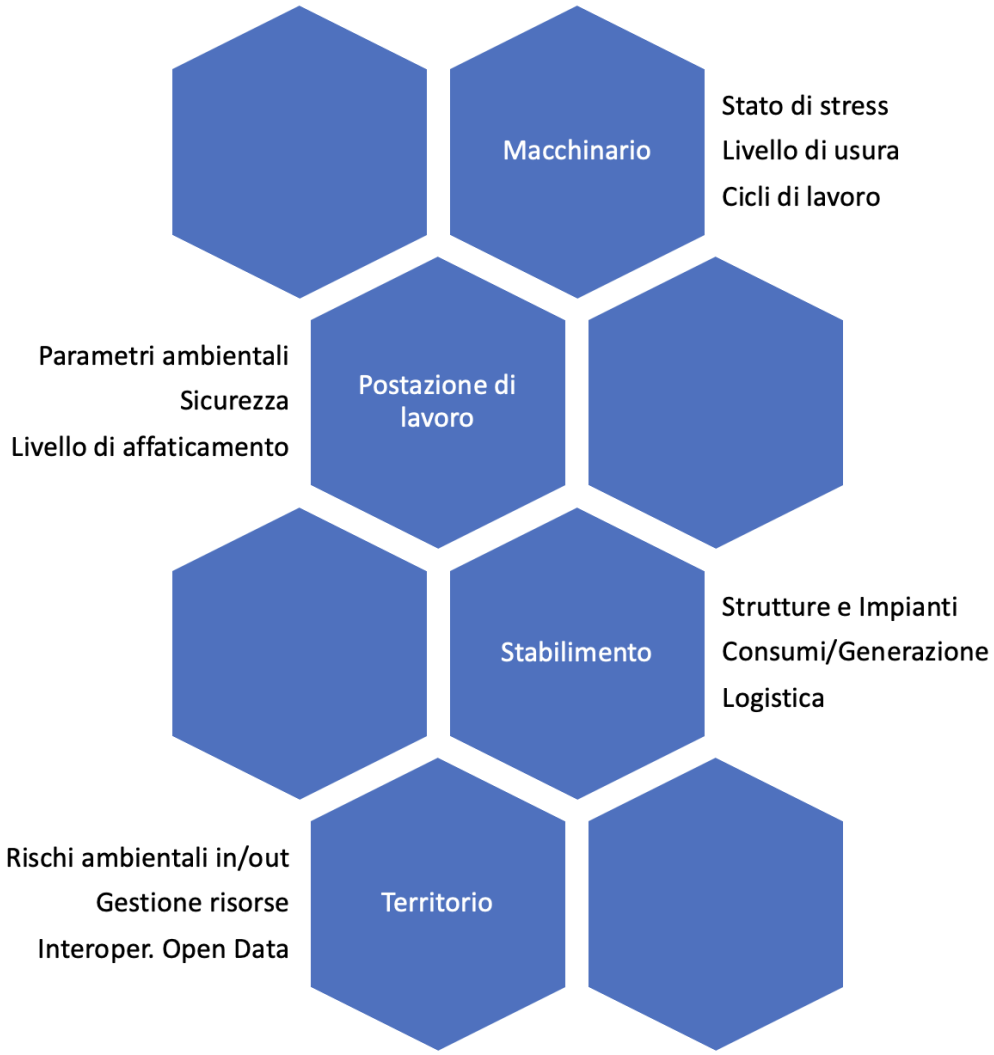
Moving towards new needs and priorities

From Industry 4.0 to Industry 5.0



Industry 5.0

Ecosystem



OUR PILLARS

OPEN SOURCE

We are doomed to know everything. The urgency is the sharing, sharing also of the good work, of free time … **Henri Antoine Groués**

OPEN HARDWARE

There is true sharing only in poverty. There is real wealth only in sharing. **Roger Etchegaray**

OWN YOUR DATA BY DESIGN

Nothing seems to me to have the least value, except what we get from ourselves. **Oscar Wilde**

Methodology

self-conscious
Systems

CLASSICAL APPROACH

sistema

[si-stè-ma] s.m. (pl. -mi)

1 Insieme di elementi coordinati tra loro in una unità funzionale; in varie tecniche, insieme delle apparecchiature e dei meccanismi predisposti per funzioni particolari: s. di ingranaggi; in fis., complesso di enti

The traditional approach to the design and implementation of a system, whatever it is, focuses on the strictly functional aspects. The issues relating to what is "external" to the system or relating to "how" the system is created or its state during operation, are relegated to the application of shared standards or procedures such as:

- General legislation, environmental impact, rules relating to the impact on health, etc .;
- Quality assurance, product certification, sizing standards, etc ..

THIS APPROACH IS QUITE LIMITED, NOR RESILIENT, NEITHER PROACTIVE

SOME EXAMPLES IN DIFFERENT SECTORS

INFRASTRUCTURES

The project ends with the testing phase.

POLICY

The focus is on the objectives (costs) without considering the *health* of the system

INDUSTRIAL SITES

The focus is on internal objectives, forgetting the external world

NEURO-BIOLOGIC APPROACH

CONSIDERS ALL THE IMPLICATIONS

REACT TO CRITICAL SITUATIONS

COMPARES RISKS AND OPPORTUNITIES

INTRODUCES PROACTIVITY

IMAGINES ALTERNATIVE STRATEGIES

CONTINUOUS INTEACTION WITH THE ENVIRONMENT

AUTO CONSCIOUS ARCHITECTURE

Inspired by neuro-biologic systems

LEFT HEMISPHERE
Serial Processor. Think linearly and methodically. Totally focused on the past and the future. Identify the details in the set of information provided by the right hemisphere, then categorizes, organizes, associates with the past and projects towards the future. It uses language, it makes us communicate. It is that voice, that buzz that tells me "I am".

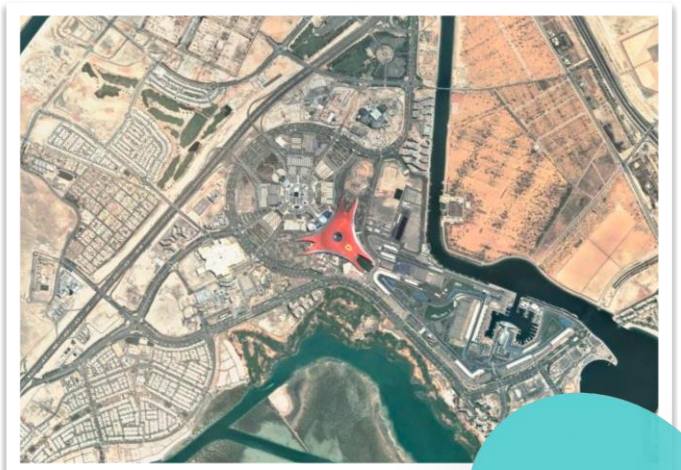
RIGHT HEMISPHERE
Parallel Processor. Totally focused on the present, here and now. Think in pictures, learn kinesthetically. Information flows simultaneously through the sensory systems as energy. It puts us in contact with the environment and with others through our senses.

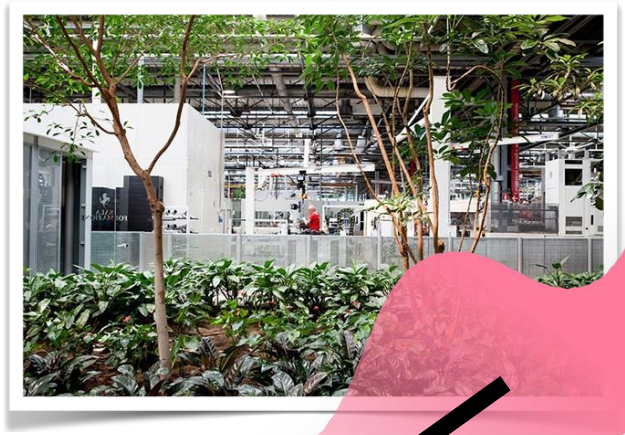
INTEROCEPTION
It is the ability to recognize sensations, stimuli. It is an internal awareness, expressed for example as: a breath, hunger, satiety, a pain, etc. These elements make me understand if everything is okay or if there is something wrong with myself.

PERCEPTION
It is the ability to acquire awareness of an external reality through the senses. For example: a color, an object, movement, etc. These elements help me understand how I am in the external environment.

THE FERRARI SYSTEM

Ferrari, the Italian Excellence that makes the world dream





FUNCTION:

BEING FERRARI MEANS BEING PART OF A UNIQUE TEAM, PROJECTED TOWARDS THE FUTURE, IN WHICH PEOPLE ARE THE MOST IMPORTANT HERITAGE.

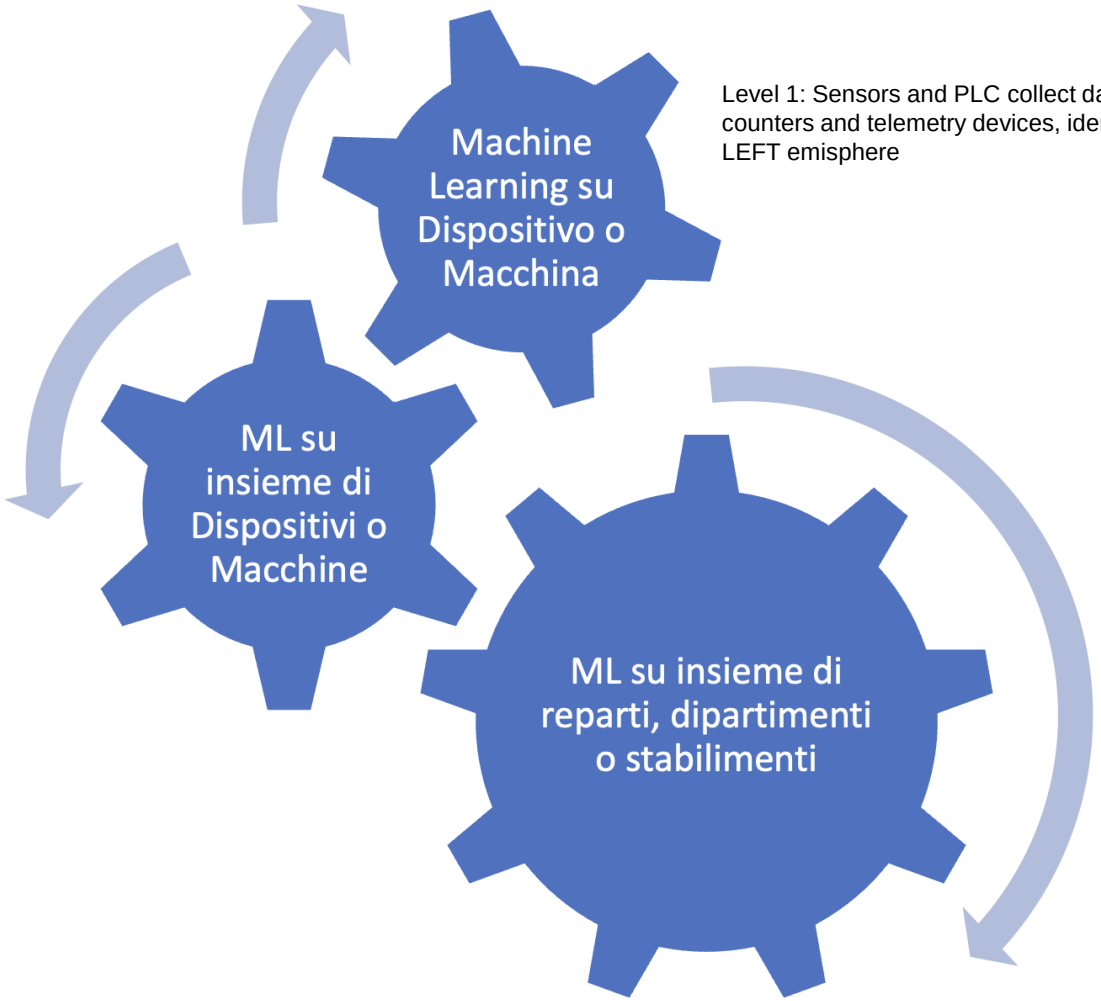
SYSTEM:

WE BUILD CARS, SYMBOL OF ITALIAN EXCELLENCE IN THE WORLD, TO WIN ON THE ROAD AND IN THE WORLDCOMPETITIONS. UNIQUE OBJECTS THAT RENEW THE MYTH OF THE HORSE CLIMBING AND GENERATE A "WORLD OF DREAMS AND EMOTIONS".

EXTERNAL:

WE DESIGN AND PRODUCE ALL THE OUR CARS IN MARANELLO, ITALY, BUT WE SELL THEM IN OVER 60 MARKETS WORLDWIDE THROUGH A NETWORK OF 180 AUTHORIZED DEALERS.

Metodology



Level 1: Sensors and PLC collect data, behave as counters and telemetry devices, identify anomalies: LEFT emisphere

Level 2: Edge devices make further elaboration, considering history and make a first simulation. Right emisphere

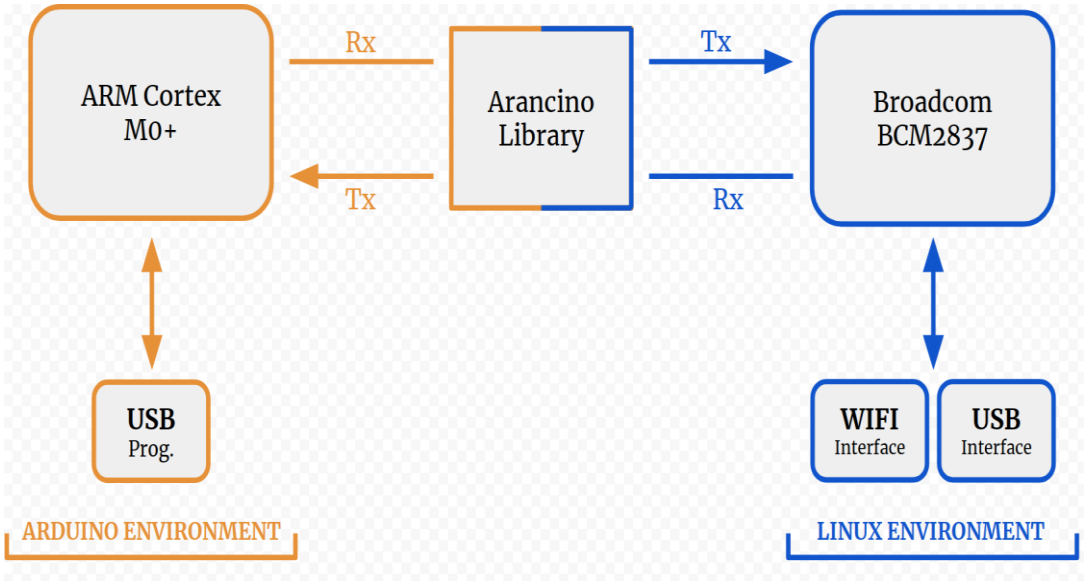
Level 3: The cloud collects, combines and synthetizes new models, that are transferred back to the edge devices at level 2. Social interaction

Arancino

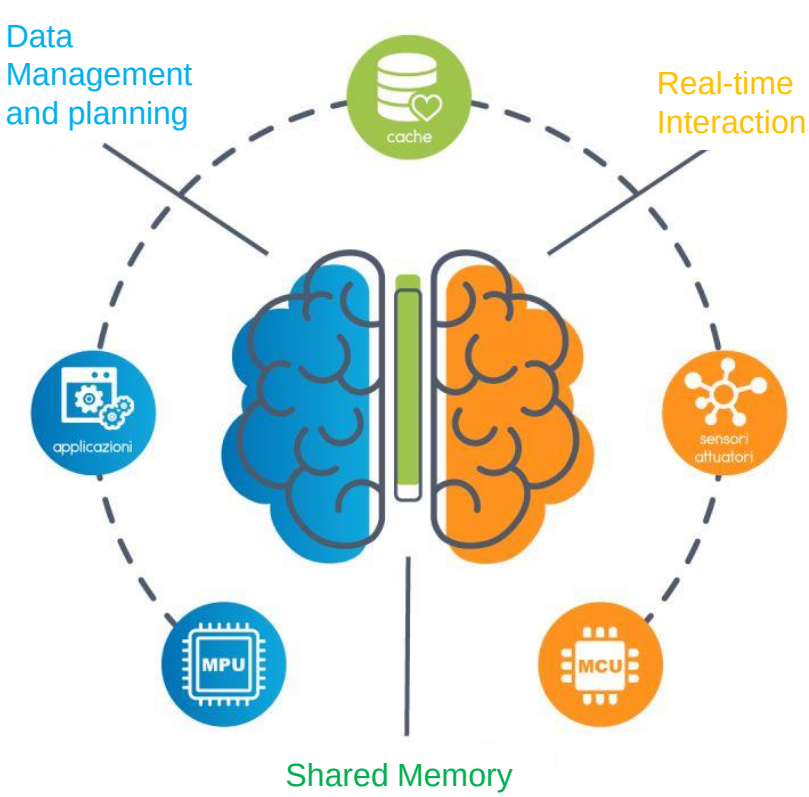
ARANCINO SMART BOARDS

arancino.cc

smartme.IO

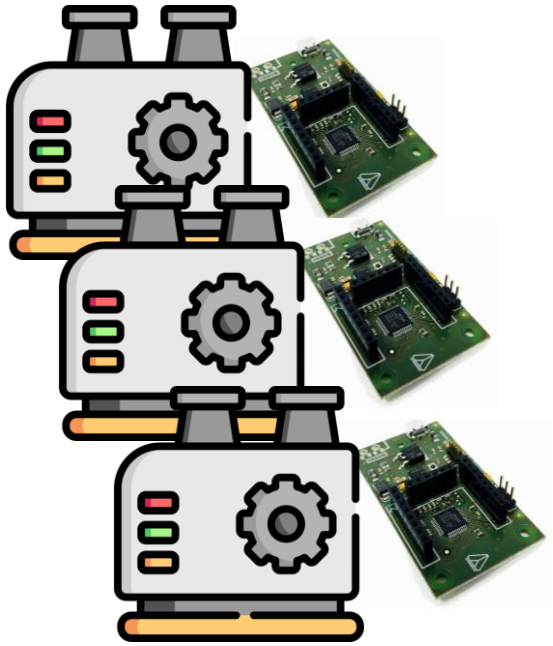


Arancino.cc architecture



From on-field monitoring to IoT applications

Machines with Arancino



Interacting with machines and sensors

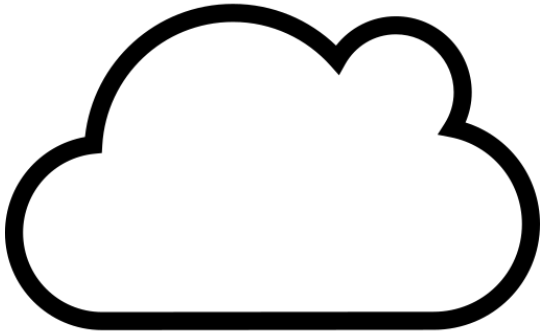
Arancino Edge

Data collection and first data analysis

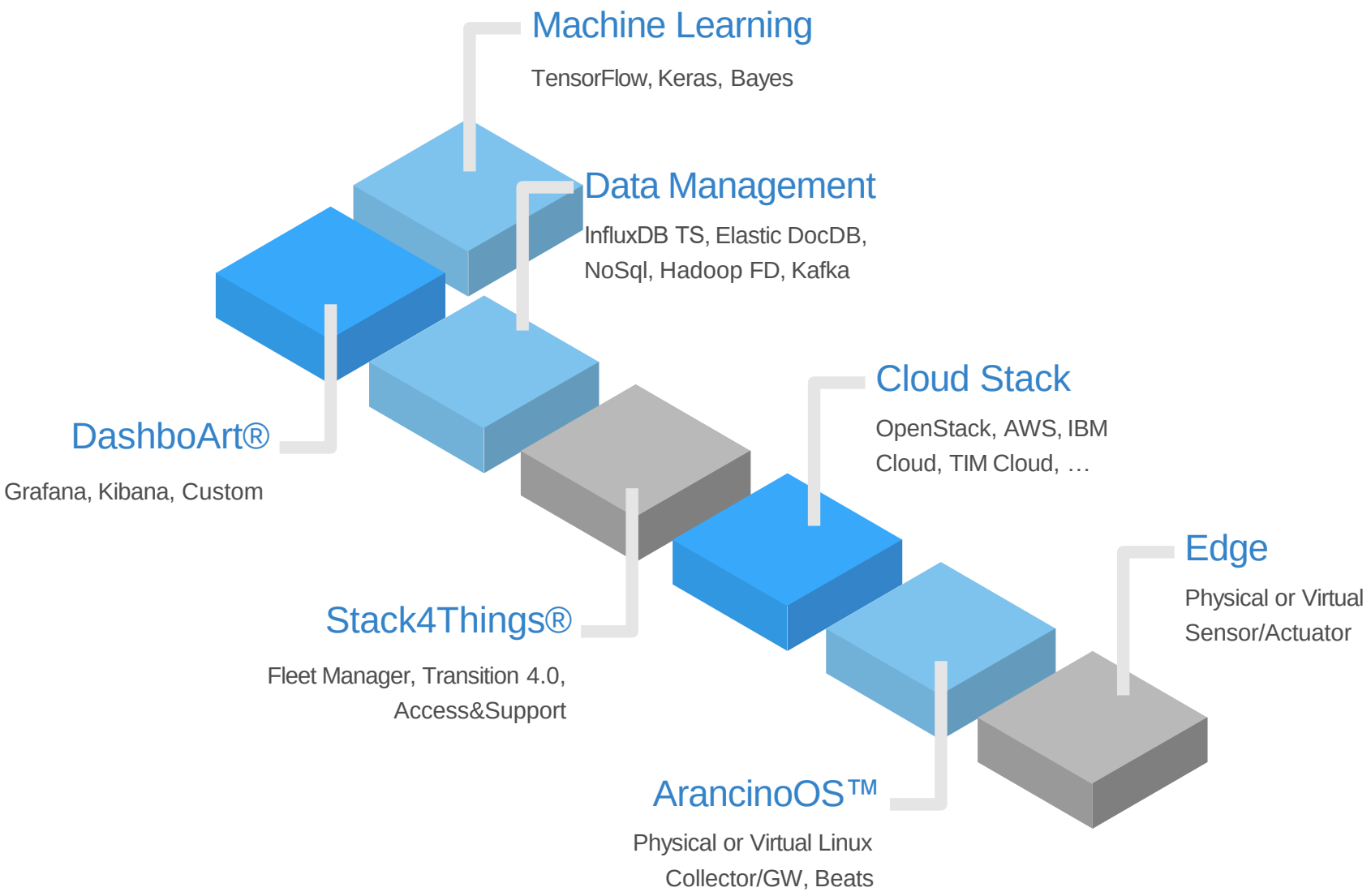
Connettivity

- Mobile EMnify
- LoRa
- Eth/WiFi

Cloud



- Machine Learning
- Data Management
- Device Management:
  - Stack4Things
  - Fleet Manager
- Events & Notify Management


Machine Learning
TensorFlow, Keras, Bayes
Data Management
InfluxDB TS, Elastic DocDB,
NoSql, Hadoop FD, Kafka
DashboArt®
Grafana, Kibana, Custom
Cloud Stack
OpenStack, AWS, IBM
Cloud, TIM Cloud, …
Edge
Physical or Virtual
Sensor/Actuator
Stack4Things®
Fleet Manager, Transition 4.0,
Access&Support
ArancinoOS™
Physical or Virtual Linux
Collector/GW, Beats

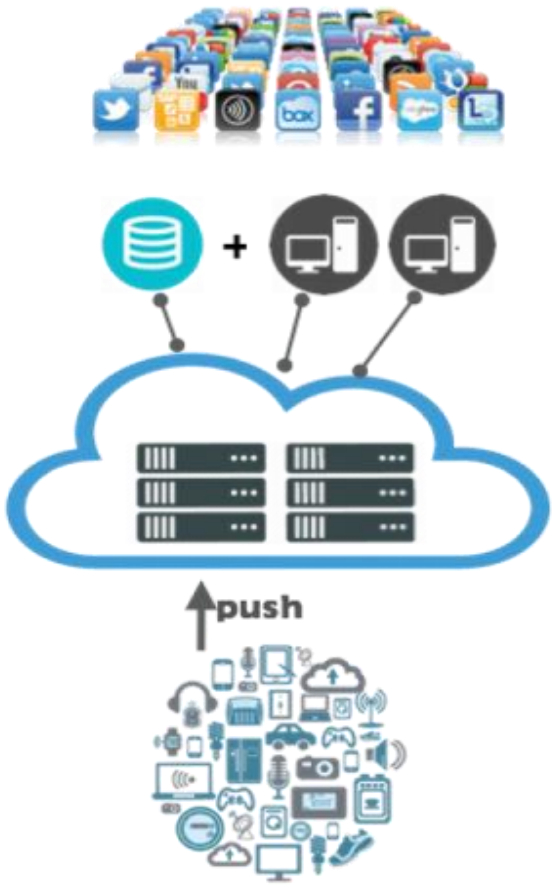
Data-oriented approach

IoT devices send data to the Cloud

Apps is built on top of standard cloud facilities VMs, storage, network)

Apps makes use of stored (non-real time) IoT data

Indirect, IoT device initiated only, retrieval of actuation commands

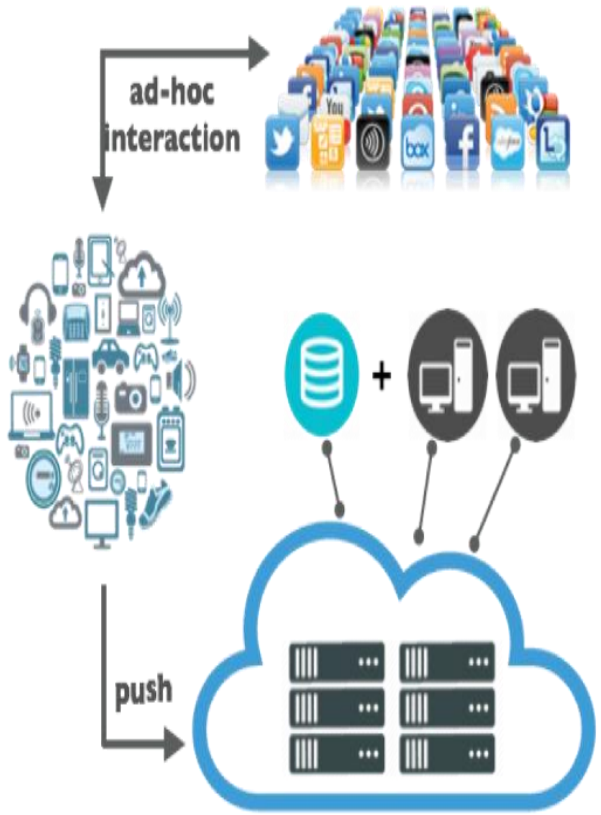


Stack4Things APPLICATION SPECIFIC (VERTICAL APPROACH)

The application uses ad-hoc mechanisms to interact with IoT devices.

No explicit interactions between Cloud components and IoT infrastructure.

Static infrastructure deployment.



I/Ocloud approach

IoT infrastructure as a natural extension of a datacenter

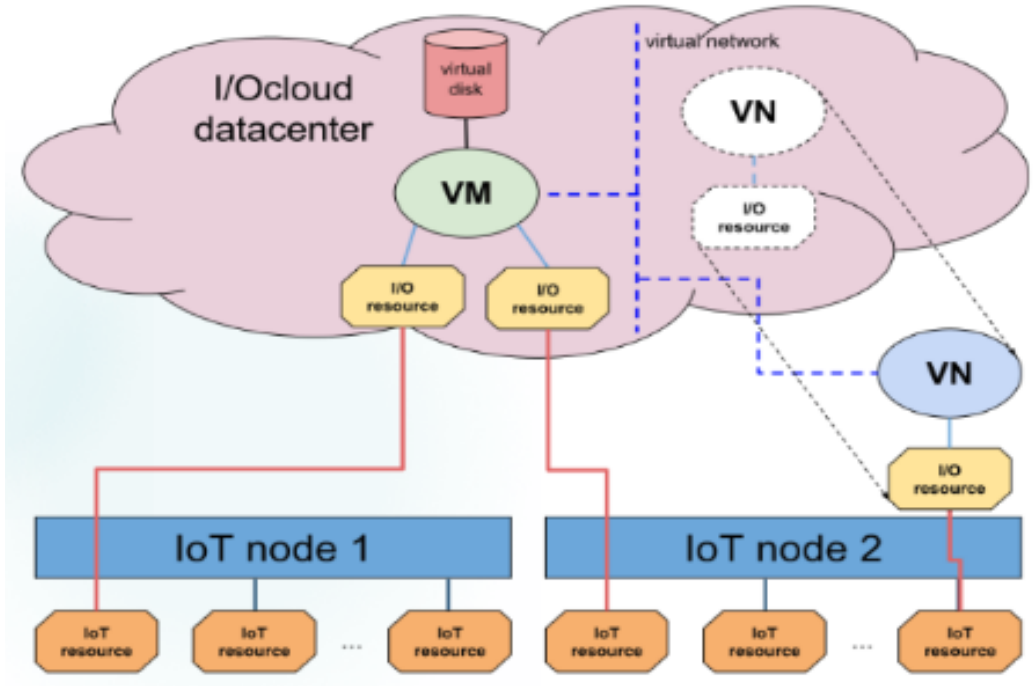
Well-defined Cloud API as a resource management interface

Separation of concerns between infrastructure and application (when needed)

From Cloud to Fog/Edge computing

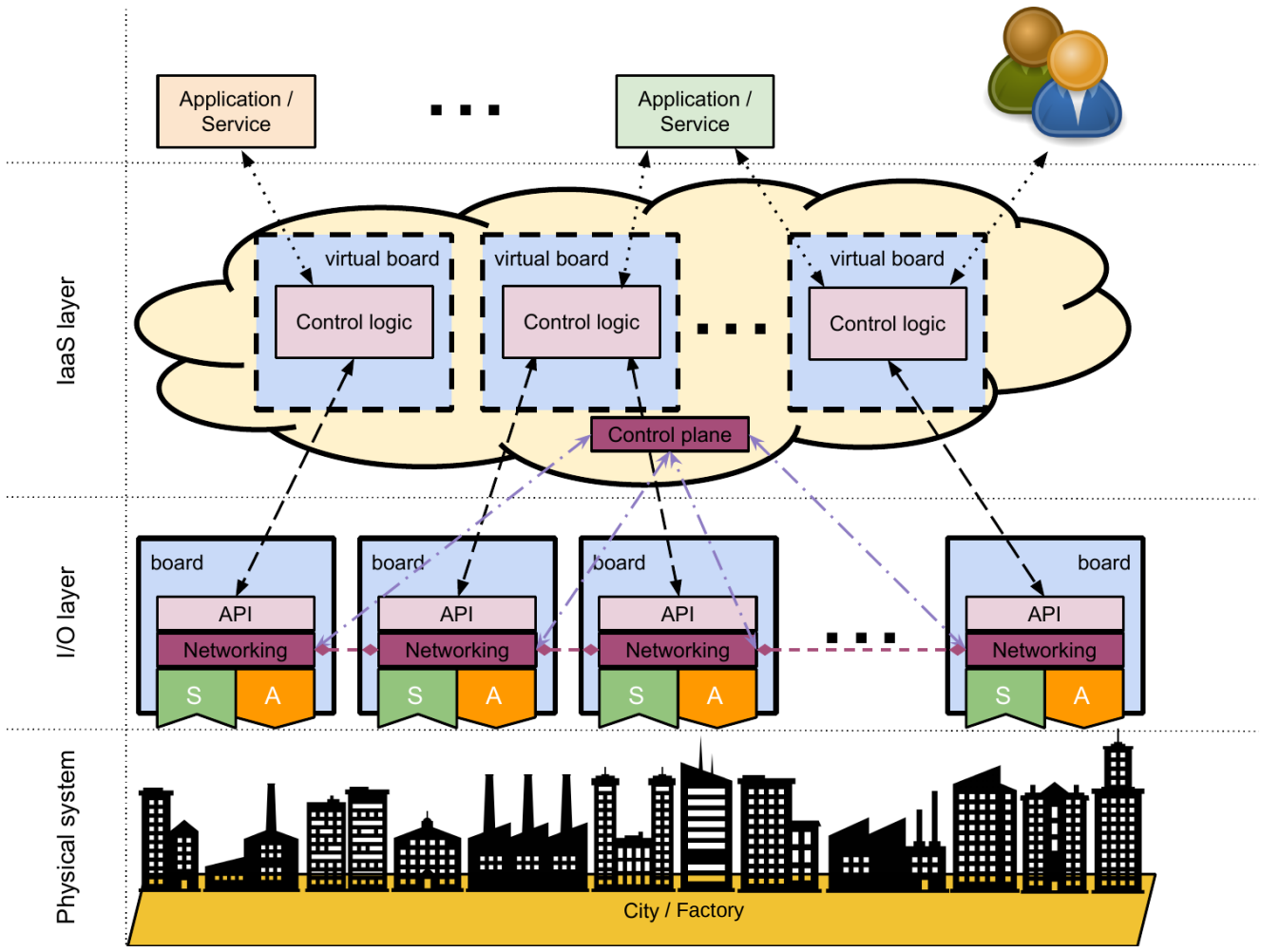
Device computation offloading

Stack4Things IoT FULL CLOUDIFICATION (I/OCLOUD APPROACH)



Approaches
(to I/O extensions for the Cloud)

Stack4Things SOFTWARE DEFINED CITIES/INDUSTRIAL SITES



Analogy with Software Defined Networking (SDN).

Extends the SD* approach to a cyber city system to enable the re-configuration of the undelying infrastructure.

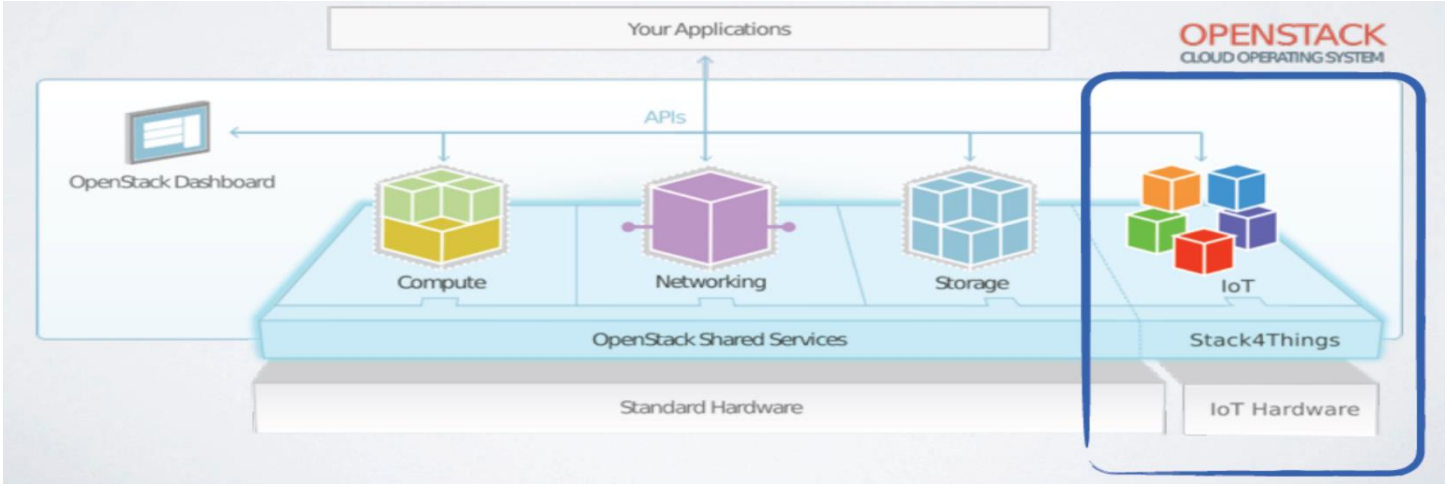
Several controllers exploit and implement the requested node topologies through generalized rules and according to predefined policies.

Stack4Things S4T & OPENSTACK

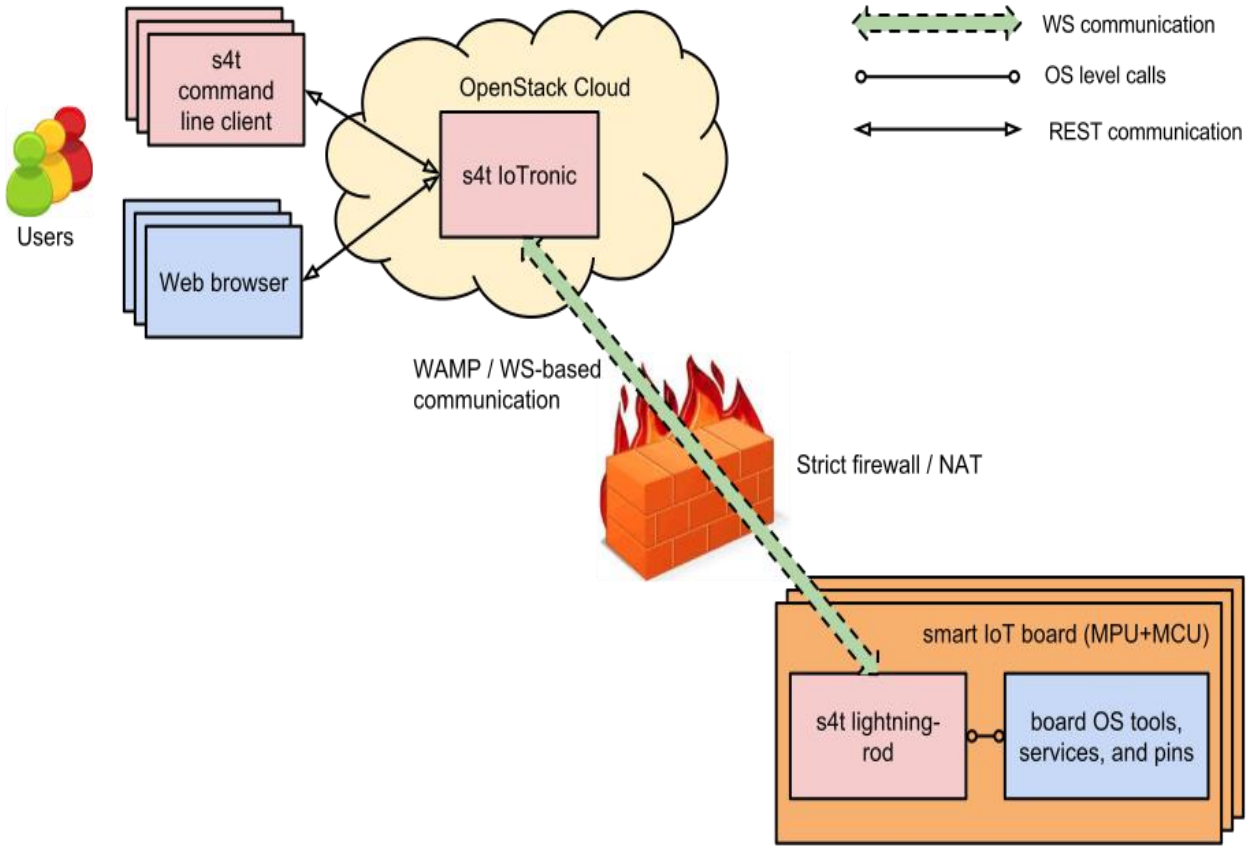
IoT resource management service for OpenStack Clouds

OpenStack (unofficial) project:

Member of the OpenStack Edge Computing group
(*https://wiki.openstack.org/wiki/Edge_Computing_Group*)
https://launchpad.net/iotronic
https://opendev.org/x/iotronic



Stack4Things HIGH-LEVEL OVERVIEW



IoT scenarios are different from Cloud-based deployments

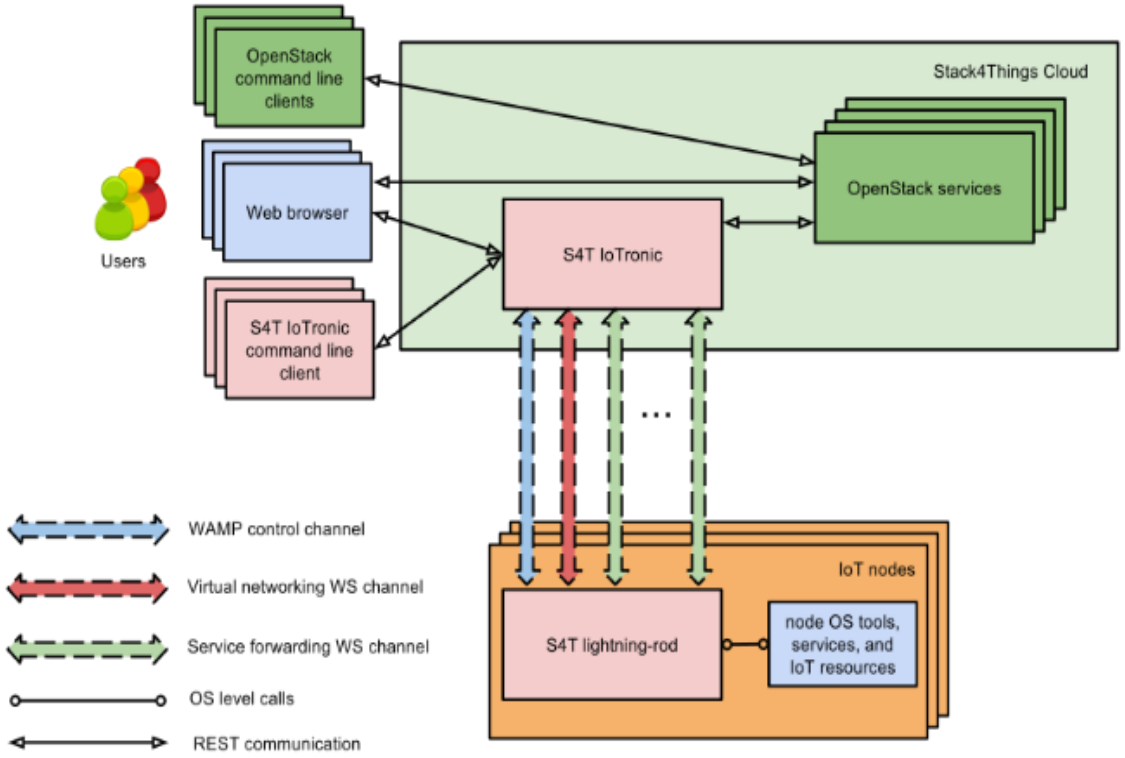
The devices are outside datacenters.

Deployed at the network Edge

Behind networking middleboxes (e.g., NATs, Firewalls)

S4T uses suitable mechanims to overwhelm the unique constraints of IoT deployments

Stack4Things HIGH-LEVEL OVERVIEW



Use of a software probe on the device-side (lightning-rod)

OpenStack compliant service (IoTronic)

Use of WAMP and plain WebSocket control channels

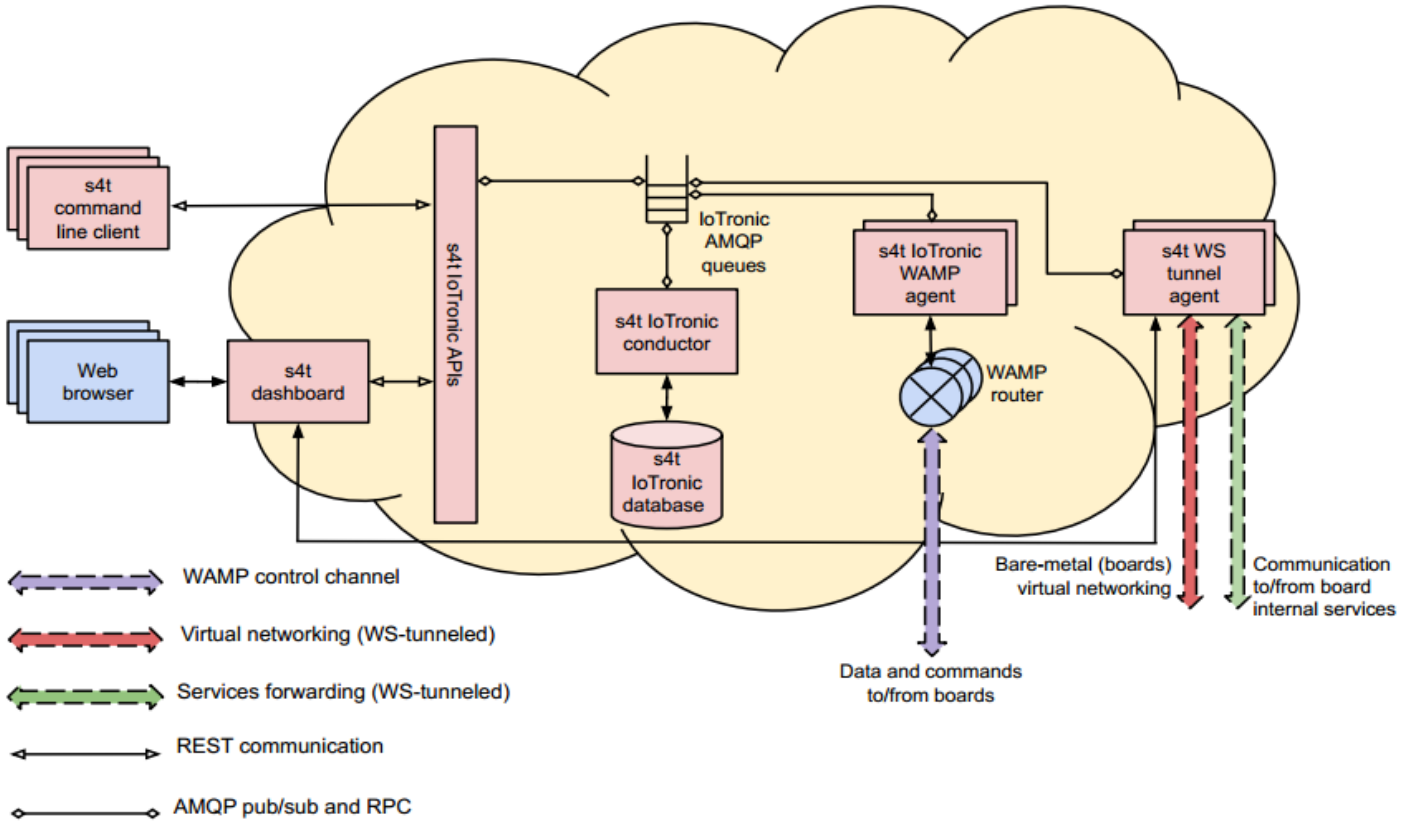
REST interfaces

Stack4Things CLOUD-SIDE ARCHITECTURE

Infrastructure management and interaction services exposed as RESTful APIs.

The Horizon dashboard as control surface for any kind of resource, including IoT-borne ones.

Deep integration with OpenStack (OS) frameworks and services, i.e., Cloud-side functionalities.



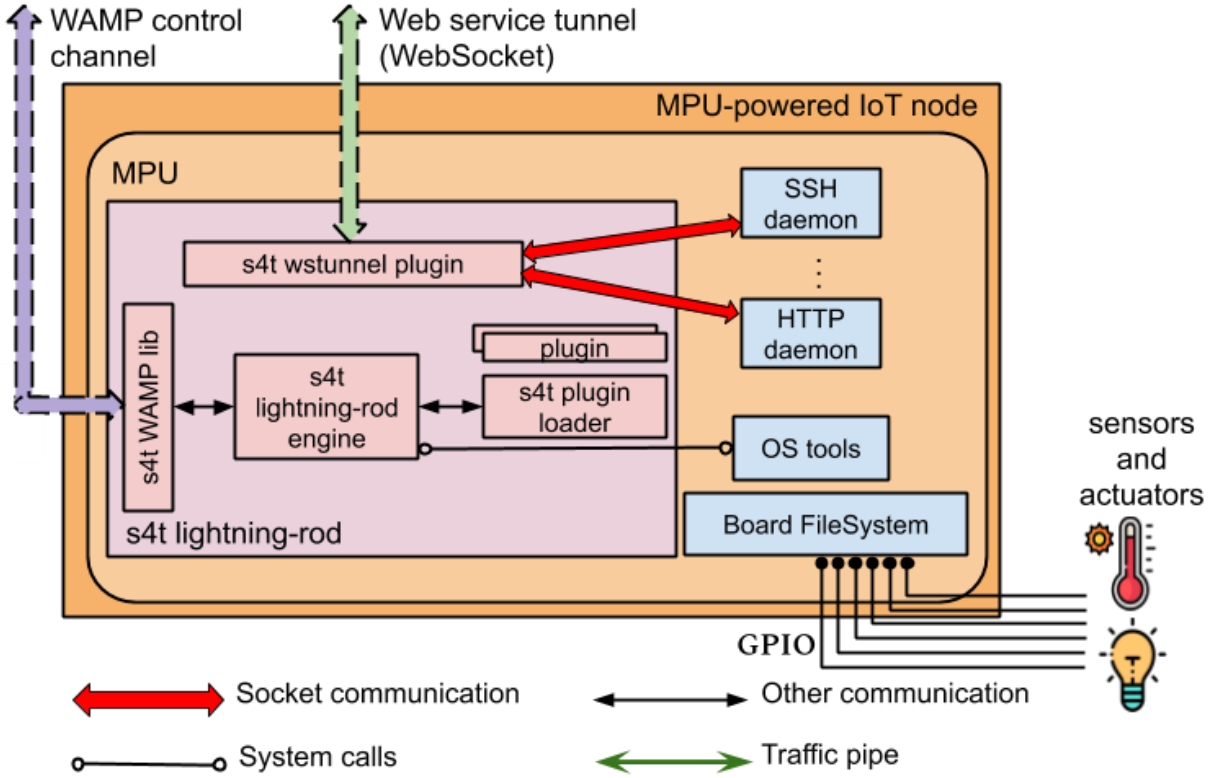
Stack4Things BOARD-SIDE ARCHITECTURE

The Lightning-Rod engine is the core of the device-side software architecture.

The engine interacts with the Cloud through WAMP protocol (i.e., pub/sub and RPCs)

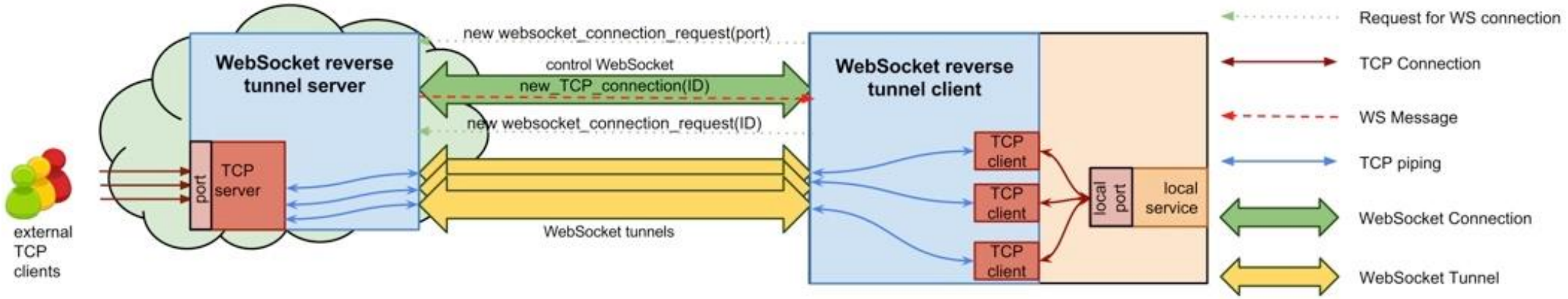
The WebSocket libraries allows the engine to act as a WebSocket reverse tunnelling server.

Custom plugins can be injected from the Cloud in order to implement specific user-defined commands



The figure shows the core services of IoTronic. Advanced functionalities are deployed by adding other components to this architecture.

Stack4Things SERVICE FORWARDING



A user can access, remotely, his/her services running on the device using the Cloud IP address.

Each service has its own (secured) Websocket tunnel.

Requests received on a specific port on the Cloud are forwarded through a Websocket tunnel.

Example:

An SSH daemon running on the board (i.e., port 22) can be exposed through the public IP address of the Cloud and a specific port.

Stack4Things VIRTUAL NETWORKING IN IOT

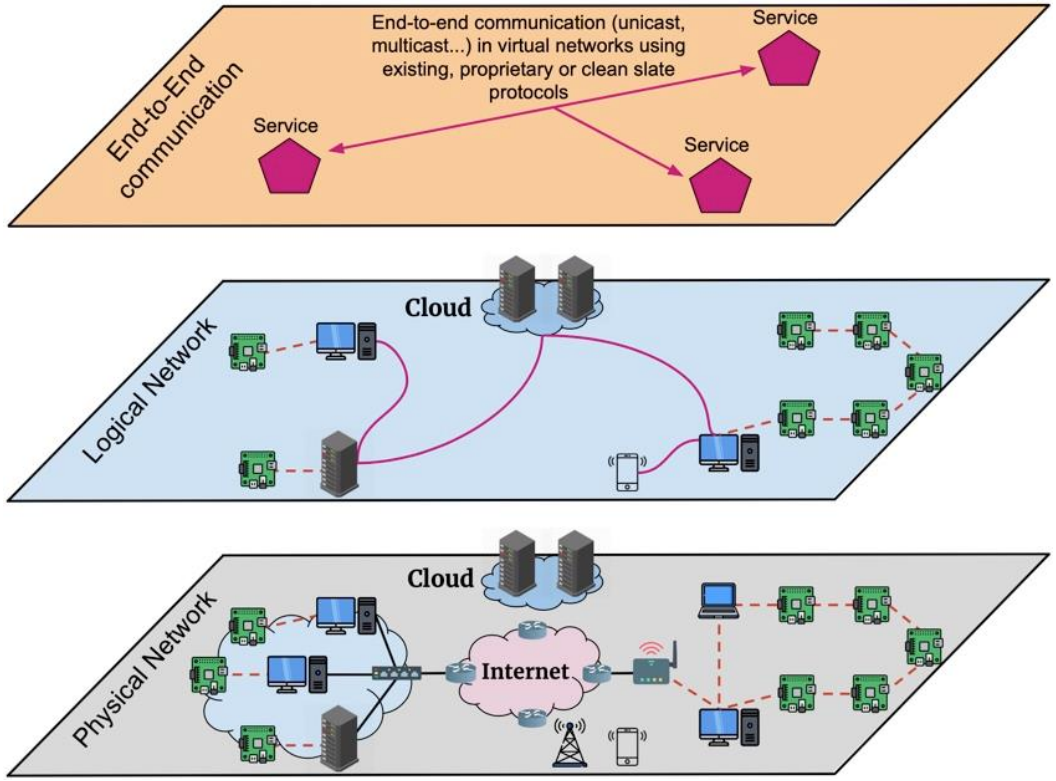
Virtualization both at the network and datalink layers enables flexible overlay networking topologies.

Infrastructure-agnostic applications.

Enable the creation of network overlays between geographically dispersed devices, we integrated Neutron, the networking subsystem of OpenStack, with our S4T middleware.

Extending the scope of applicability of service discovery protocols (e.g., AllJoyn).

Virtual networks may span both (datacenter-hosted) VMs and virtual IoT devices.



Stack4Things VIRTUAL NETWORKING IN IOT

Integration of S4T with the OpenStack Networking subsystem, Neutron.

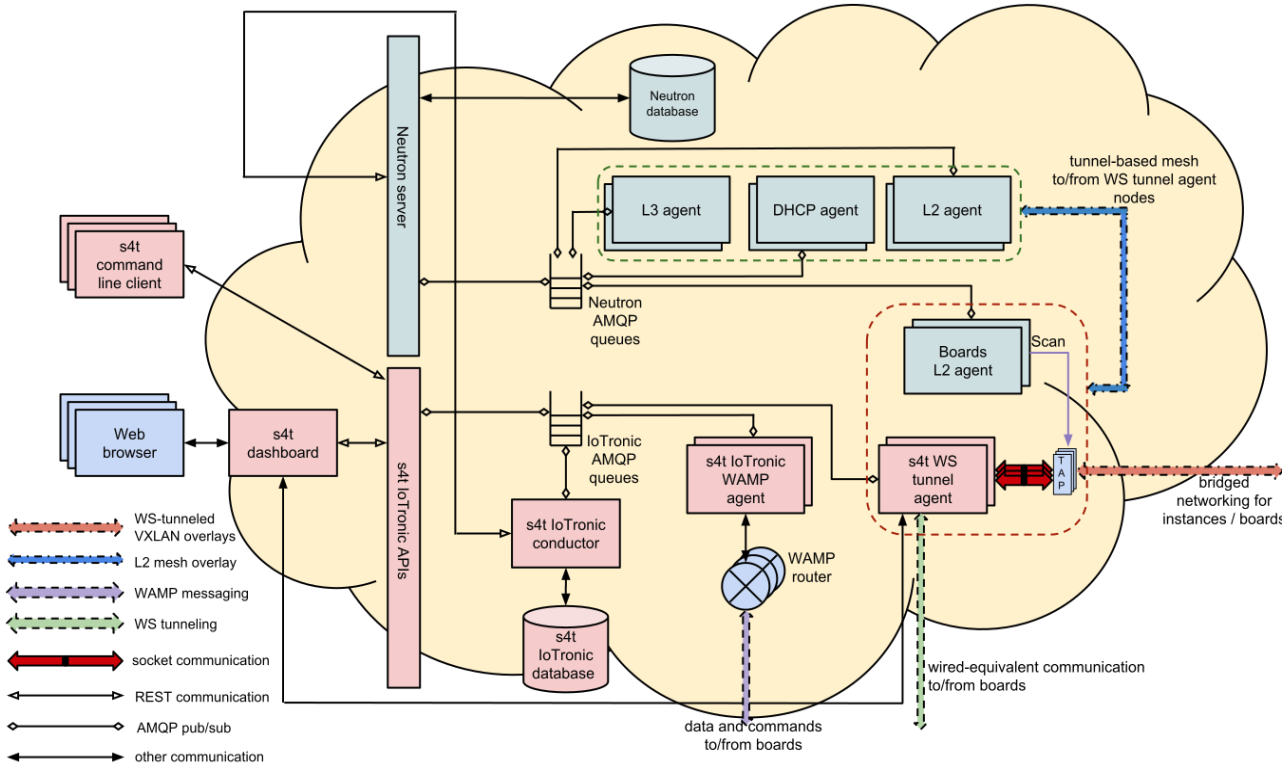
Extending Neutron capabilities to deal with IoT deployments constraints.

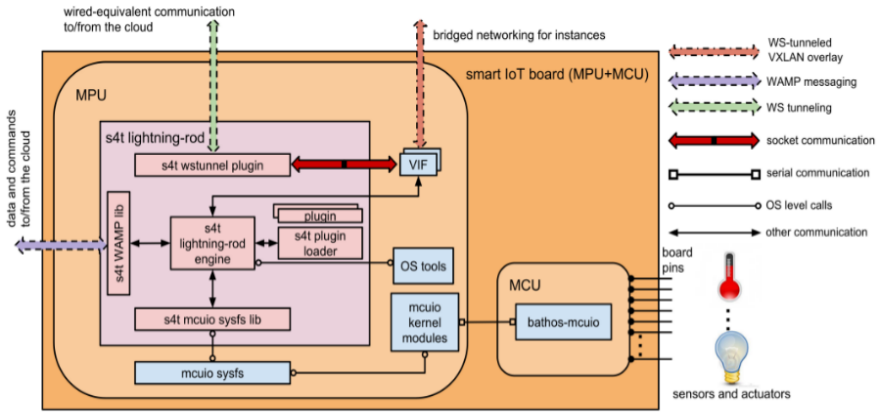
Boards are totally unaware about network virtualization duties and Neutron.

Virtual Networking equipment (e.g., virtual switches) are deployed on the Cloud.

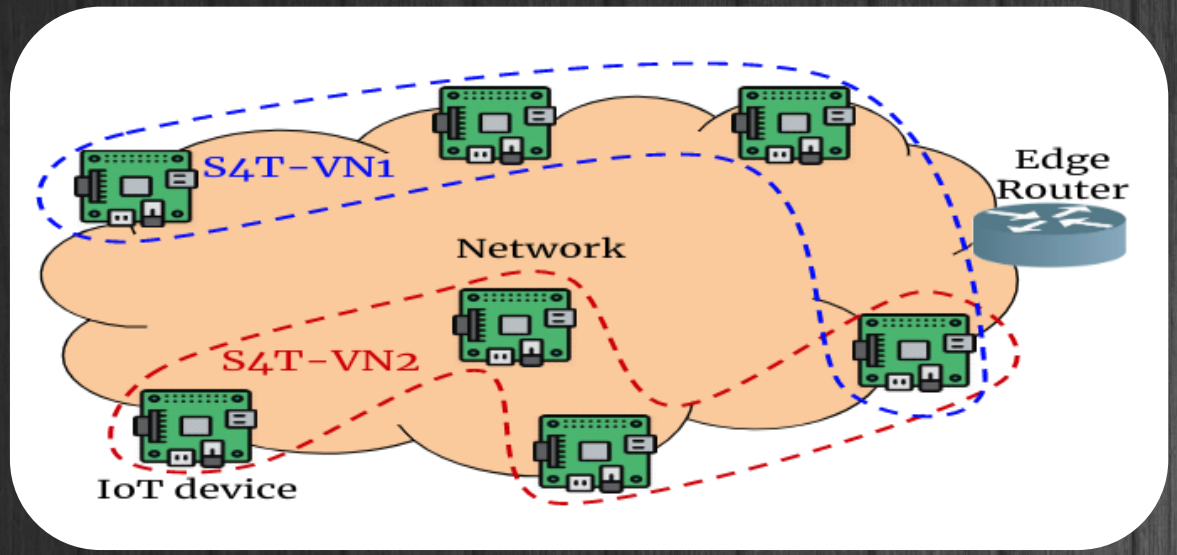
Only virtual interfaces (i.e., TAP class devices) are created on the devices.

The overall footprint of the solution is inherently lightweight for the boards.

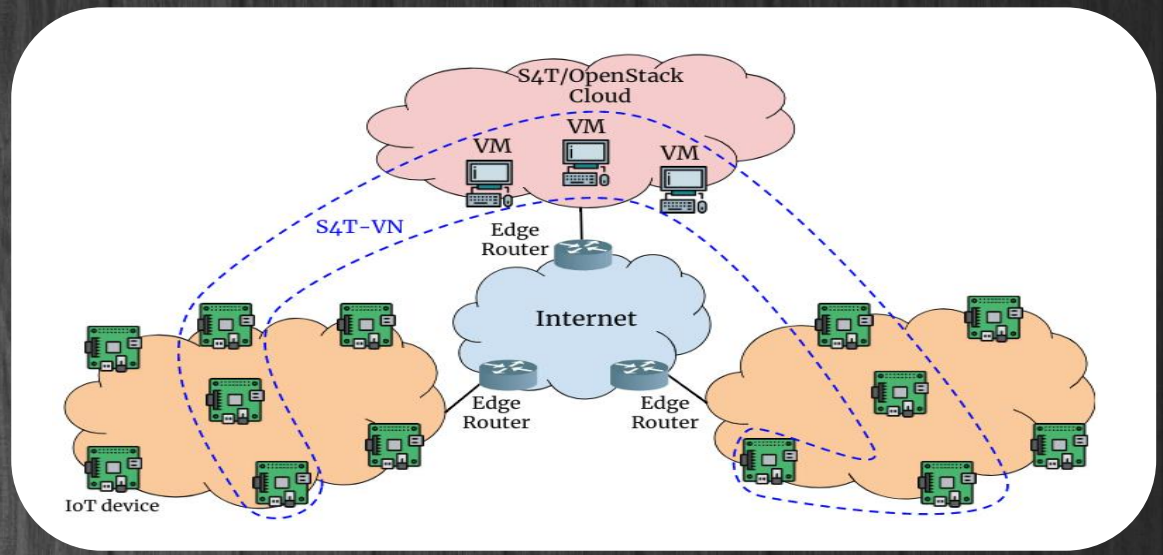




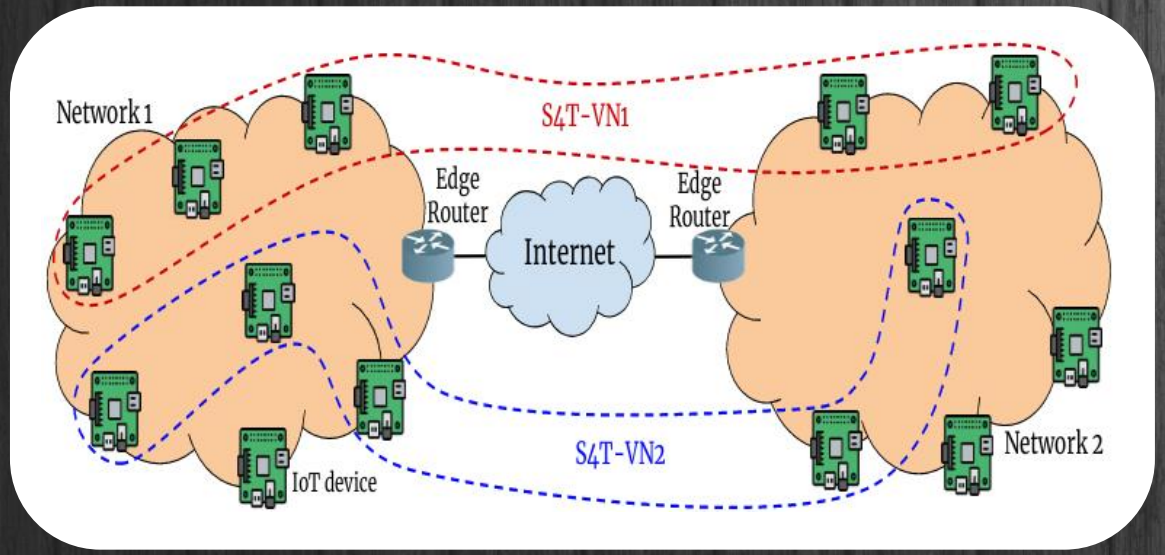
Stack4Things VIRTUAL NETWORKING IN IOT



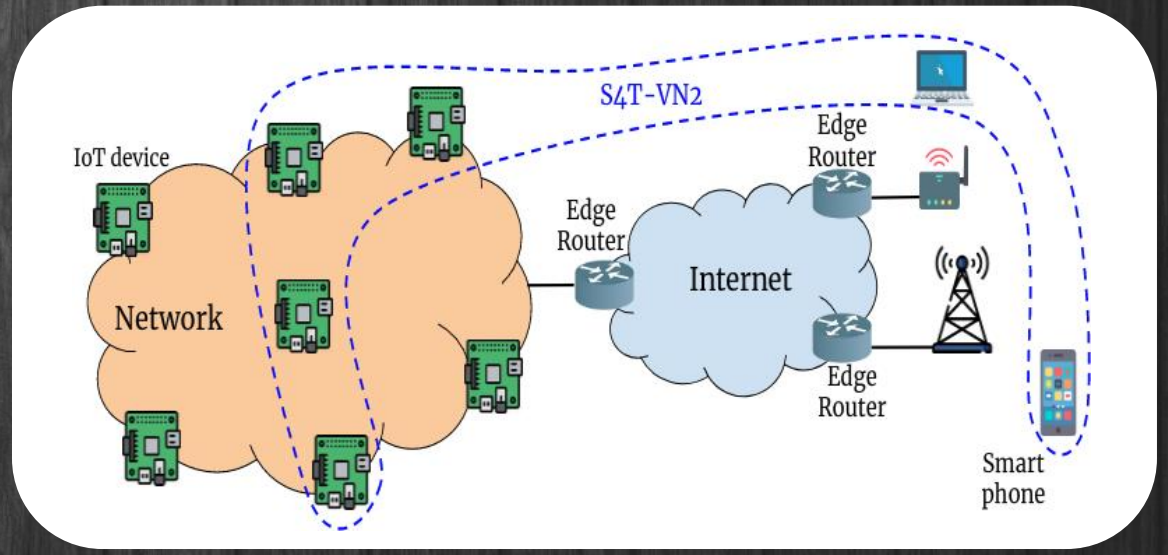
USE CASE 1



USE CASE 3



USE CASE 2



USE CASE 4

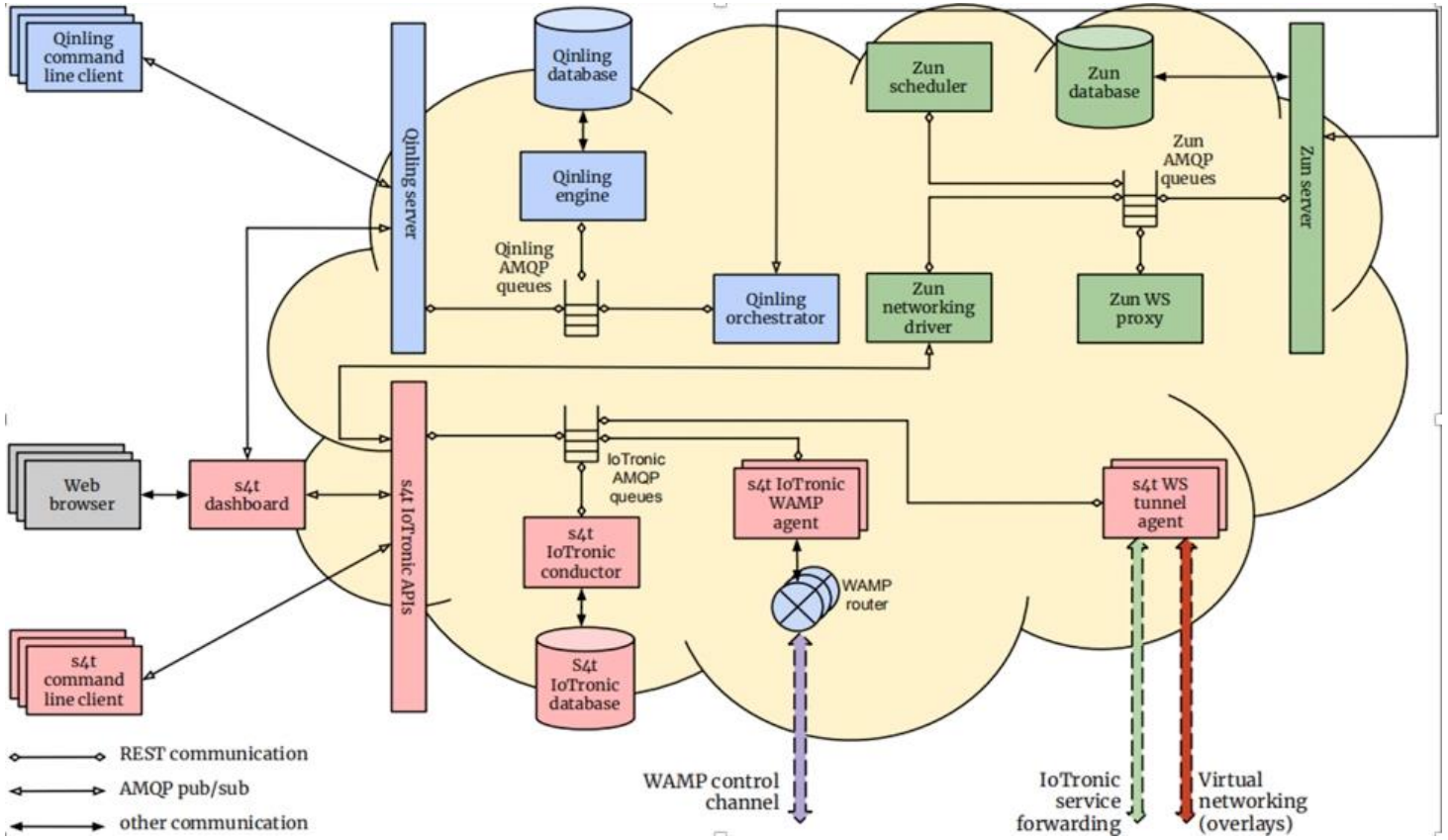
Stack4Things EDGE FUNCTION-AS-A-SERVICE (FaaS)

S4T provides the capability to conceive applications involving IoT devices based on the FaaS/Serverless paradigm.

Functions can be injected on remote IoT devices and then executed/triggered by particular events (i.e., event-driven).

We make use of the Cloud-oriented OpenStack services Qinling (Serverless subsystem) and Zun (containers management subsystem).

IoTronic is used as a networking driver for Zun/Qinling.



Stack4Things EDGE FUNCTION-AS-A-SERVICE (FaaS)

Use case: Create IoT pipelines/dataflows involving geo-distributed devices and their hosted resources (i.e., sensors and actuators)

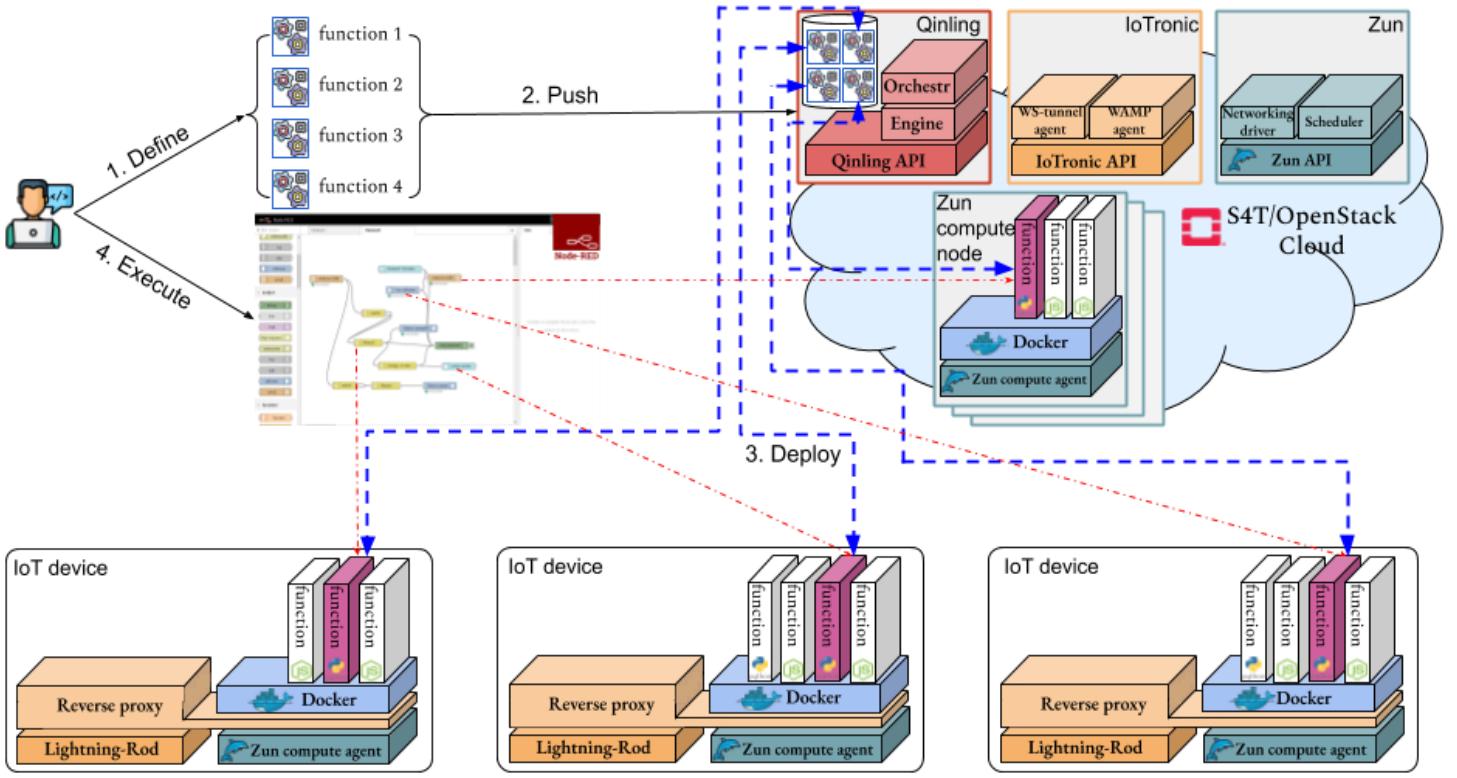
Node-Red blocks are instantiated on the devices as FaaS functions.

Functions deployed on the Cloud-side can be also involved (i.e., more compute resources).

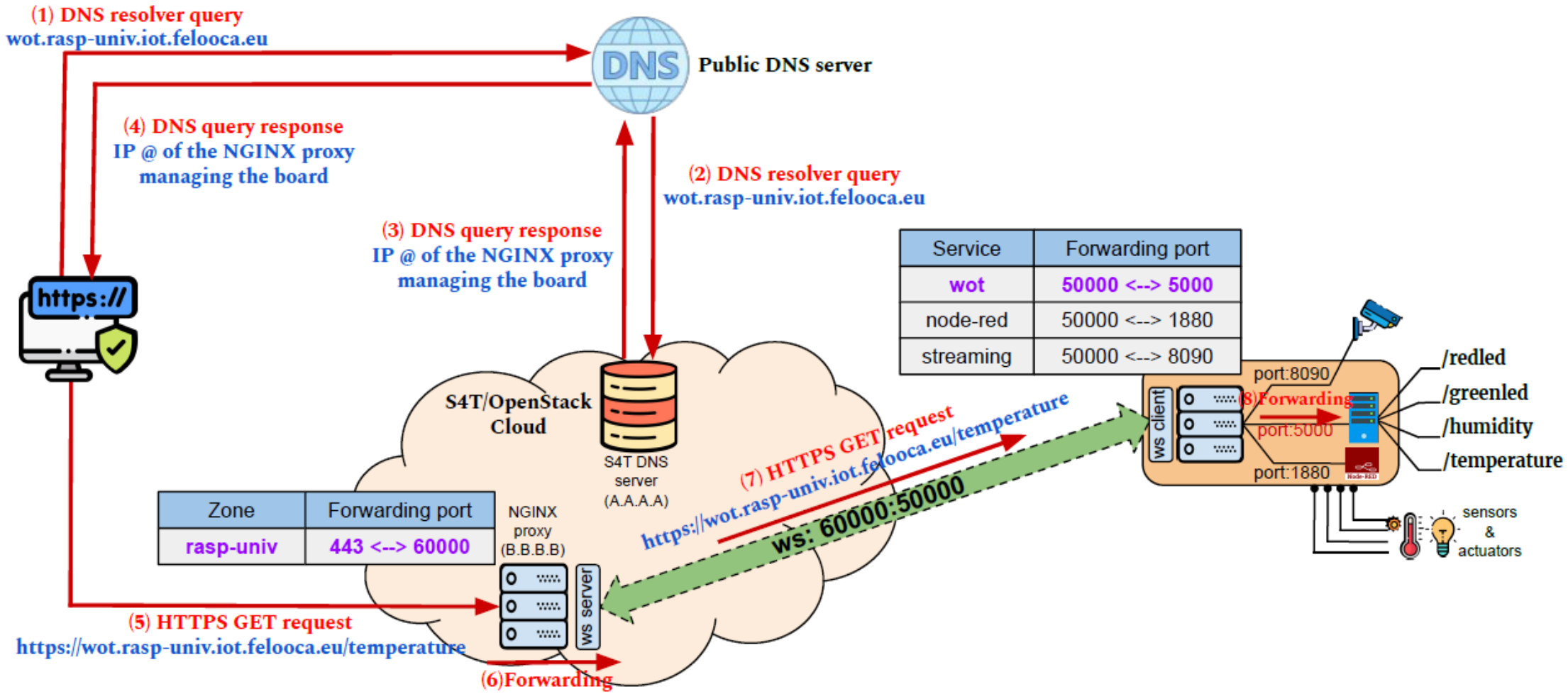
OpenStack/Qinling is used as a centralized repository for the custom actions.

For applications involving 'serverless' logic in the cloud, S4T can provide a standard way to package, deploy and manage functions/actions across the cloud and the edge.

You can conveniently develop custom logic for the IoT devices in programming languages other than JavaScript (e.g., Python).

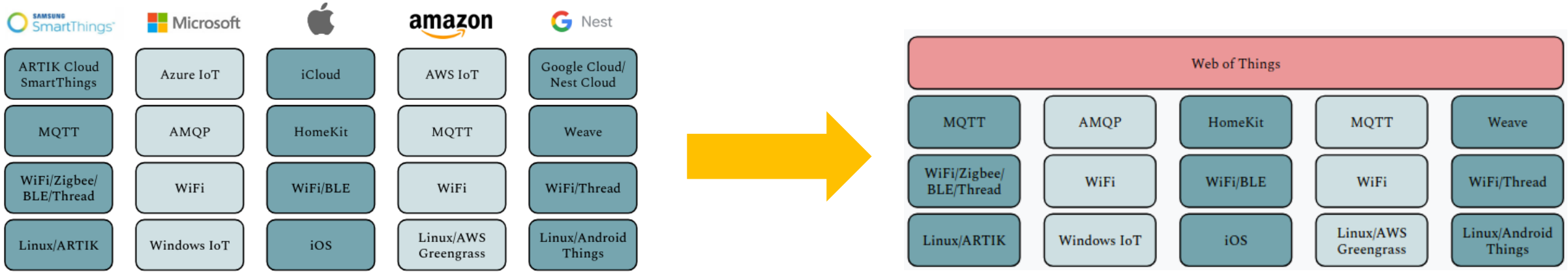


Stack4Things WEB OF THINGS



Stack4Things WEB OF THINGS

Everything as a Resource



Use case: Stack4Things Web services are used to enable the Web of Things paradigm (WoT).

The WoT paradigm aims at making IoT devices/resources an integral part of the Web.

By exposing Web servers running on the IoT devices, we can expose sensors and actuators as Web resources.

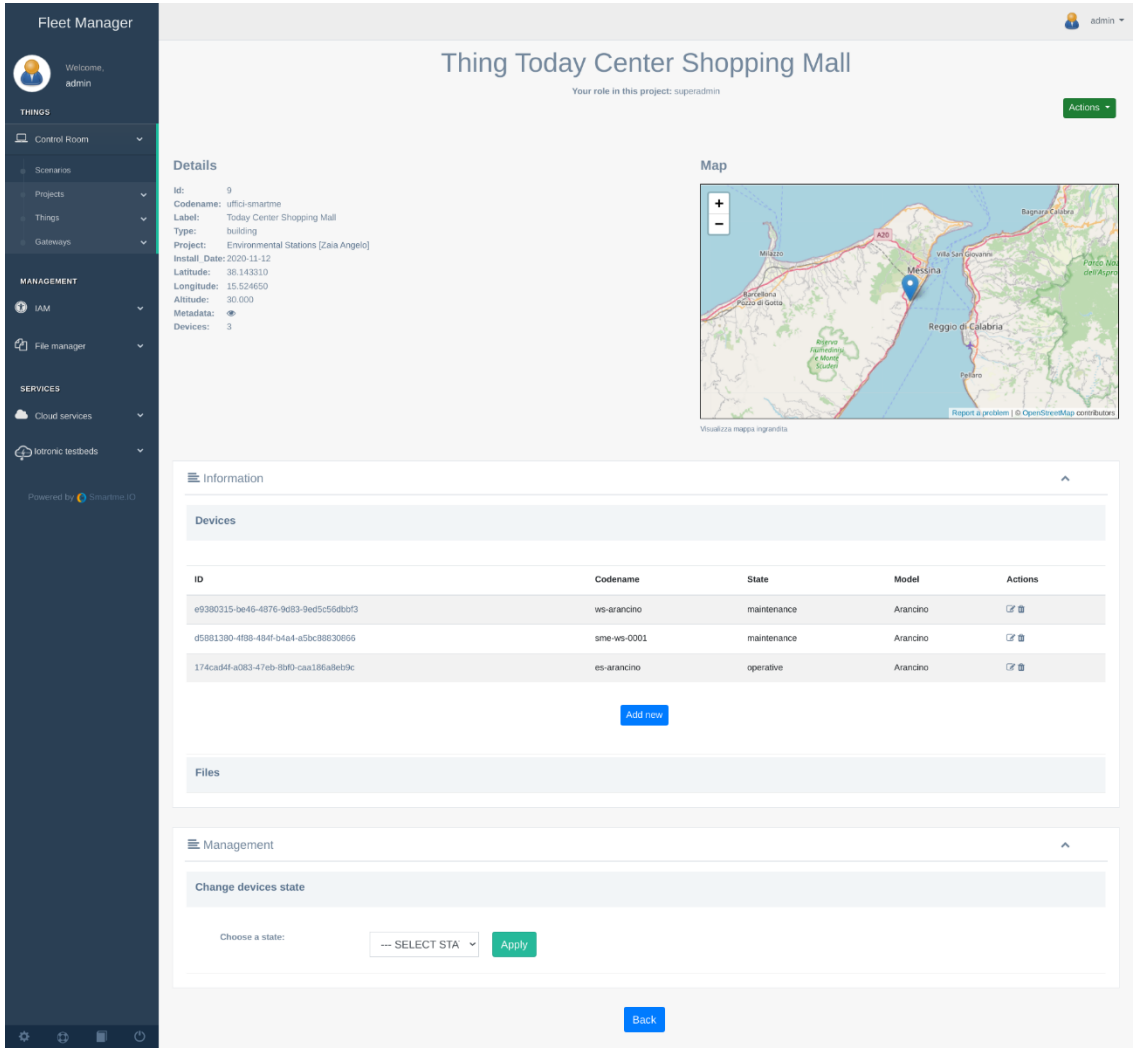
Smart things become easier to build upon popular Web languages (e.g., HTML, Python, JavaScript, PHP) can be used to easily build applications involving smart things

Demo: https://wot.rasp-univ.iot.felooca.eu/

All interactions here are HTTPS based.

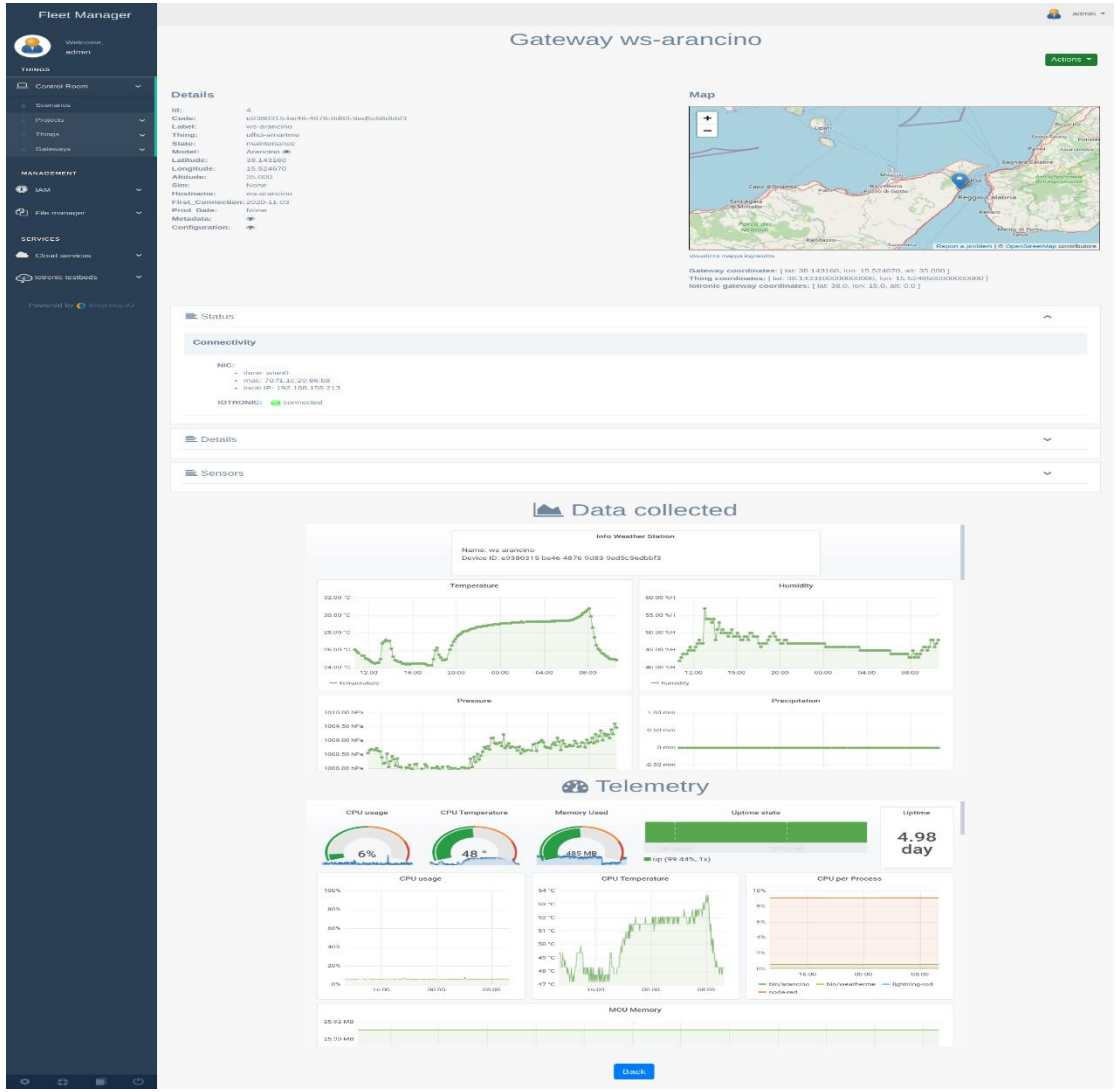
Stack4Things

Portal for fleet management 1/2



Stack4Things

Portal for fleet management 2/2



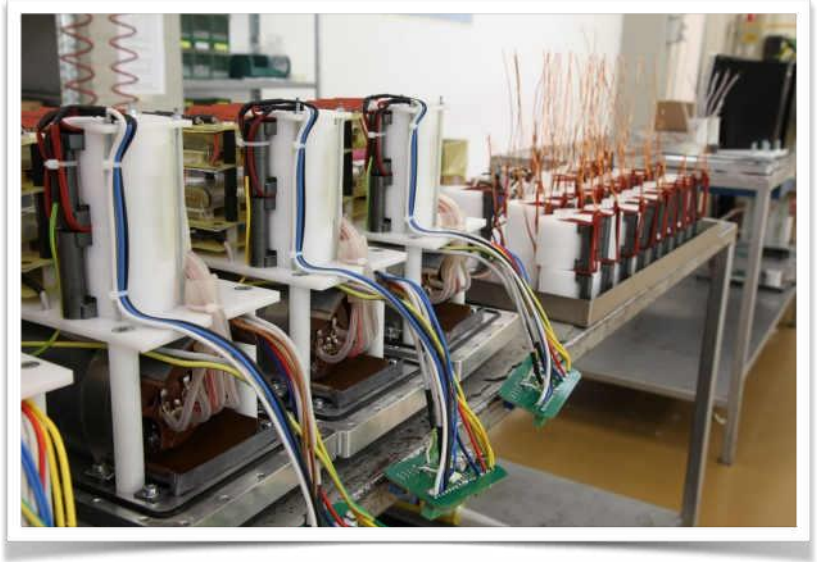
OUR CLIENTS


STELLANTIS
moz://a
a2a
AGENZIA MOBILITÀ AMBIENTE TERRITORIO
Comune di Milano
CITTA' DI TORINO
PADOVANET
Città di Lecce
Città di Siracusa
Patrimonio dell'umanità
WOLFSBURG
Città di Messina
Città Metropolitana di Messina
Cremona
COMUNE DI CREMONA
SACERTIS
PLASTITALIA
high performance fittings
kirey group
Fondazione di Comunità di Messina
EMILCAMION
insirio
GRUPPO GIOMI
La tua salute la nostra missione
TECNOKAR
TRAILERS
Politecnico di Torino
ISMB
FUTURE IS OUR FOCUS
EEng SA
PASSION FOR INNOVATION
HDMgroup
STADIA
IOTEAM
MERIDIONALE IMPIANTI
la Cristallina

TRAILERS

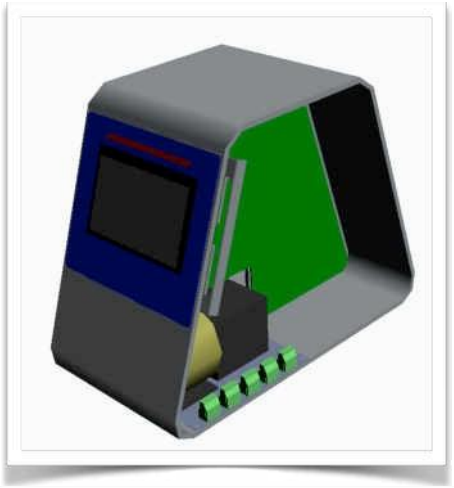
FIRMWARE + HARDWARE + MGMT CLOUD

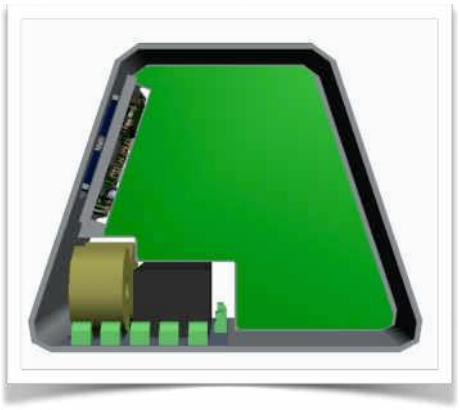
MEDICAL DEVICES FIRMWARE + HARDWARE

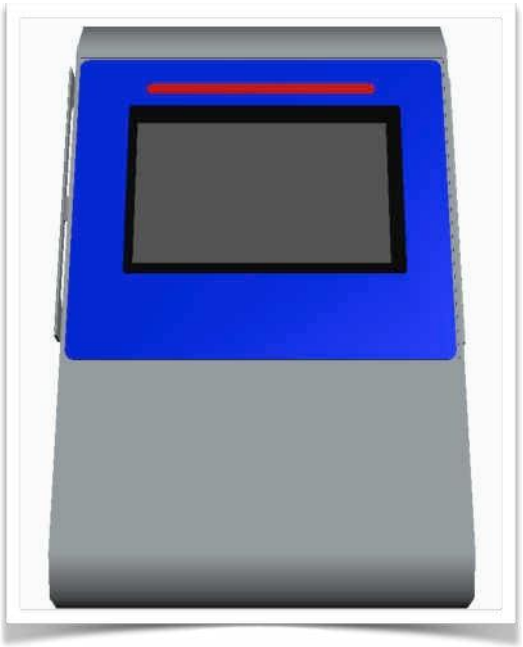


SALDATRICI

FIRMWARE + HARDWARE + MGMT CLOUD

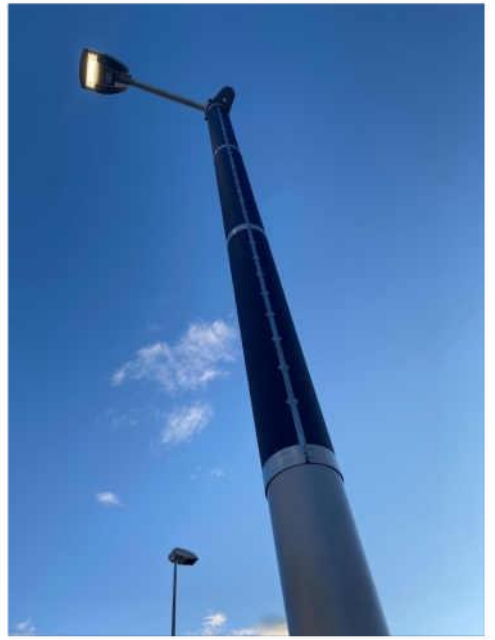


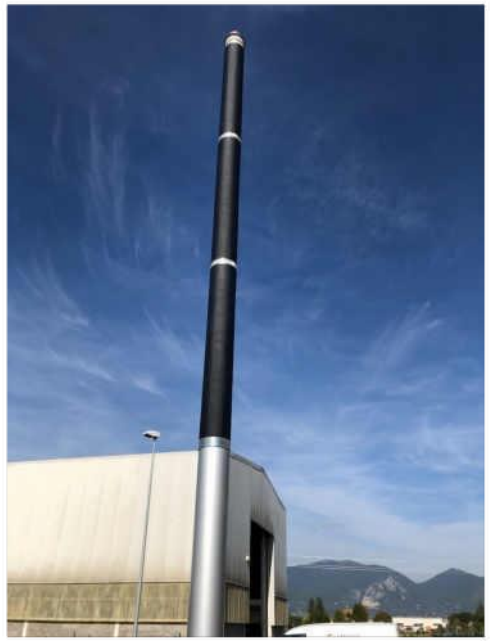




SMART LIGHTING

FIRMWARE + HARDWARE + MGMT CLOUD

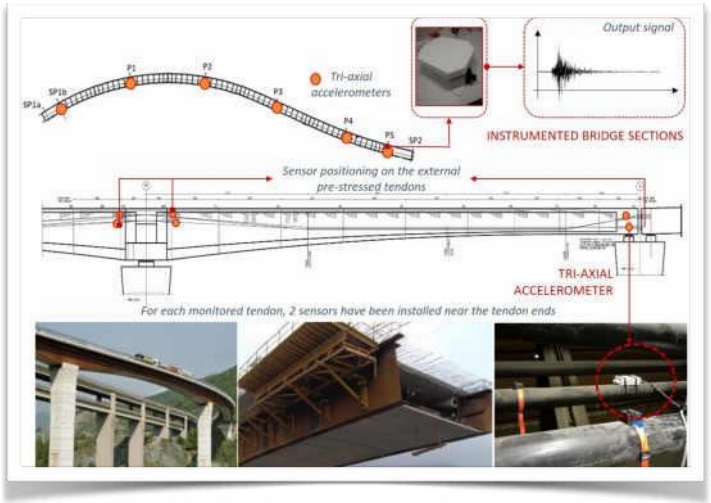


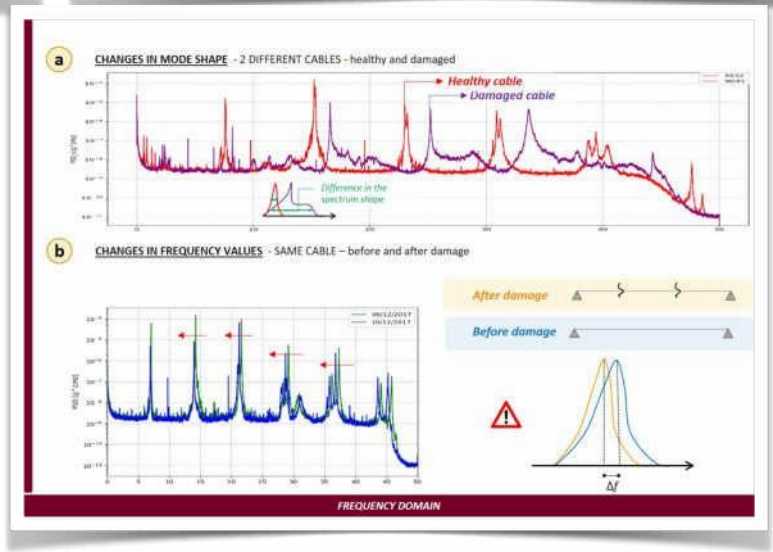


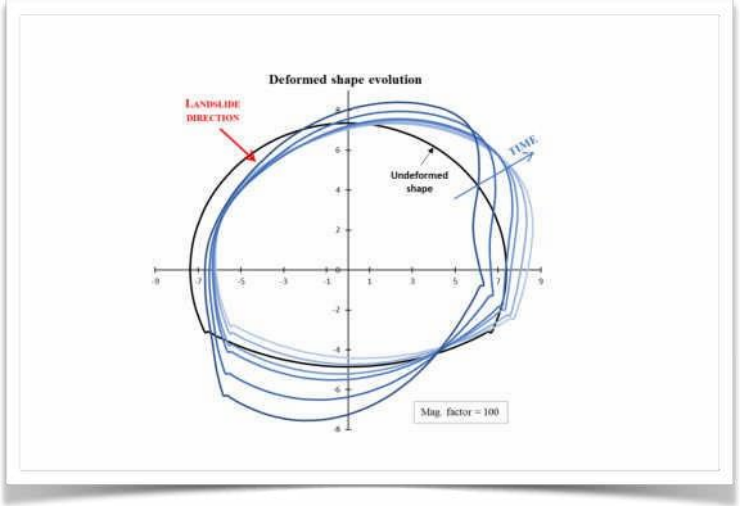
RE-CHARGE STATIONS

FIRMWARE + HARDWARE

INFRASTRUCTURES MONITORING

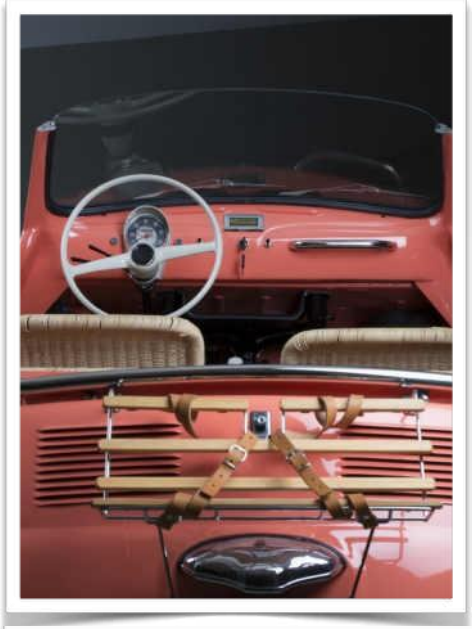


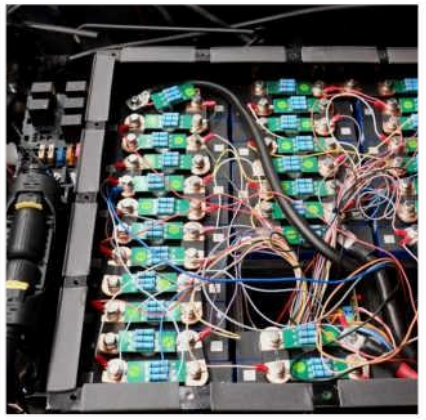




ELECTRIC CARS

FIRMWARE + MGMT CLOUD



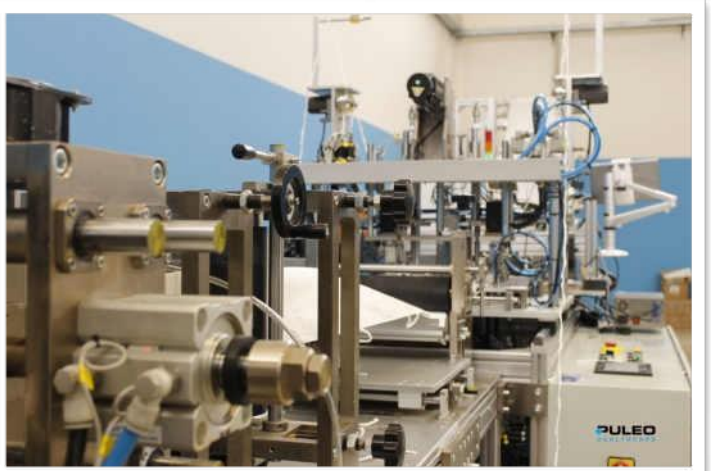


FOOD INDUSTRY

FIRMWARE + MGMT CLOUD

COVID MASKS

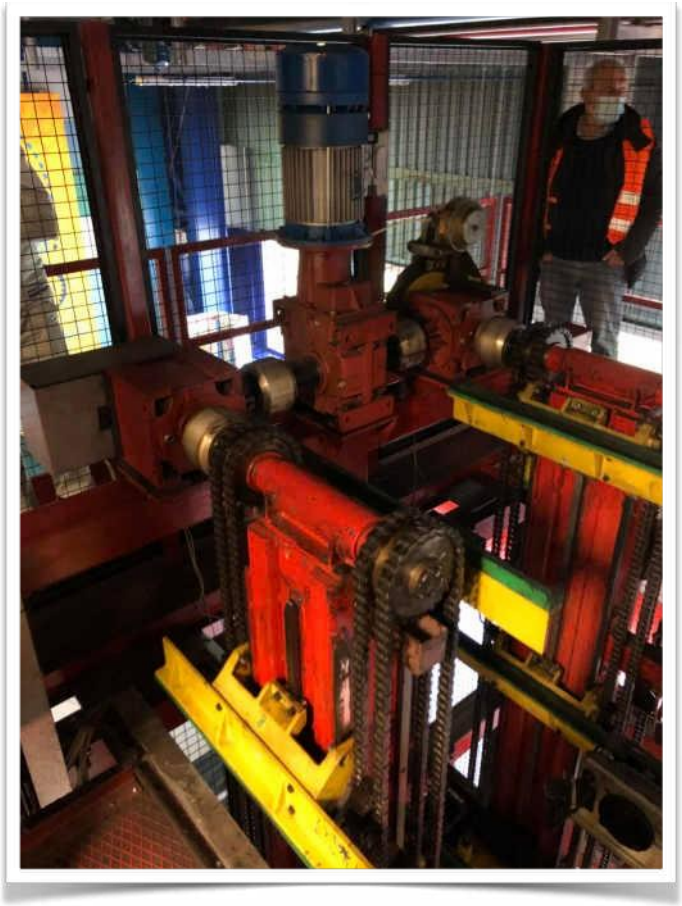
FIRMWARE + MGMT CLOUD



PREDICTIVE MAINTENANCE

FIRMWARE + HARDWARE, ML

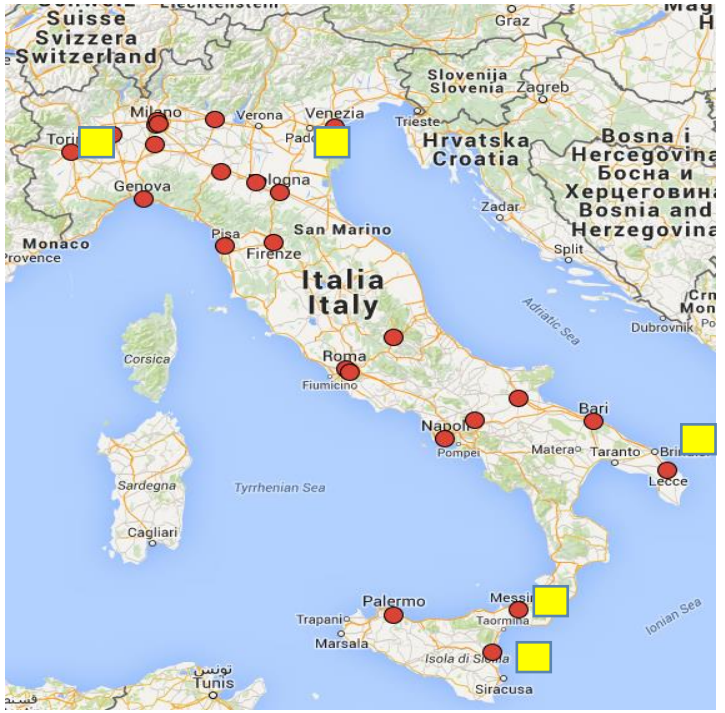
smartme.IO



#SmartME services TOO(L) SMART

TOO(L) smart is a **reuse** and evolution of the #SmartMe “good practice” that involves **TORINO PADOVA MESSINA LECCE** and **SIRACUSA**

The goal of project is to transform urban systems into a network of objects capable of taking an active role, interacting with each other, with citizens and with the PAs thanks to the paradigms of the Internet of Things and Cloud Computing.



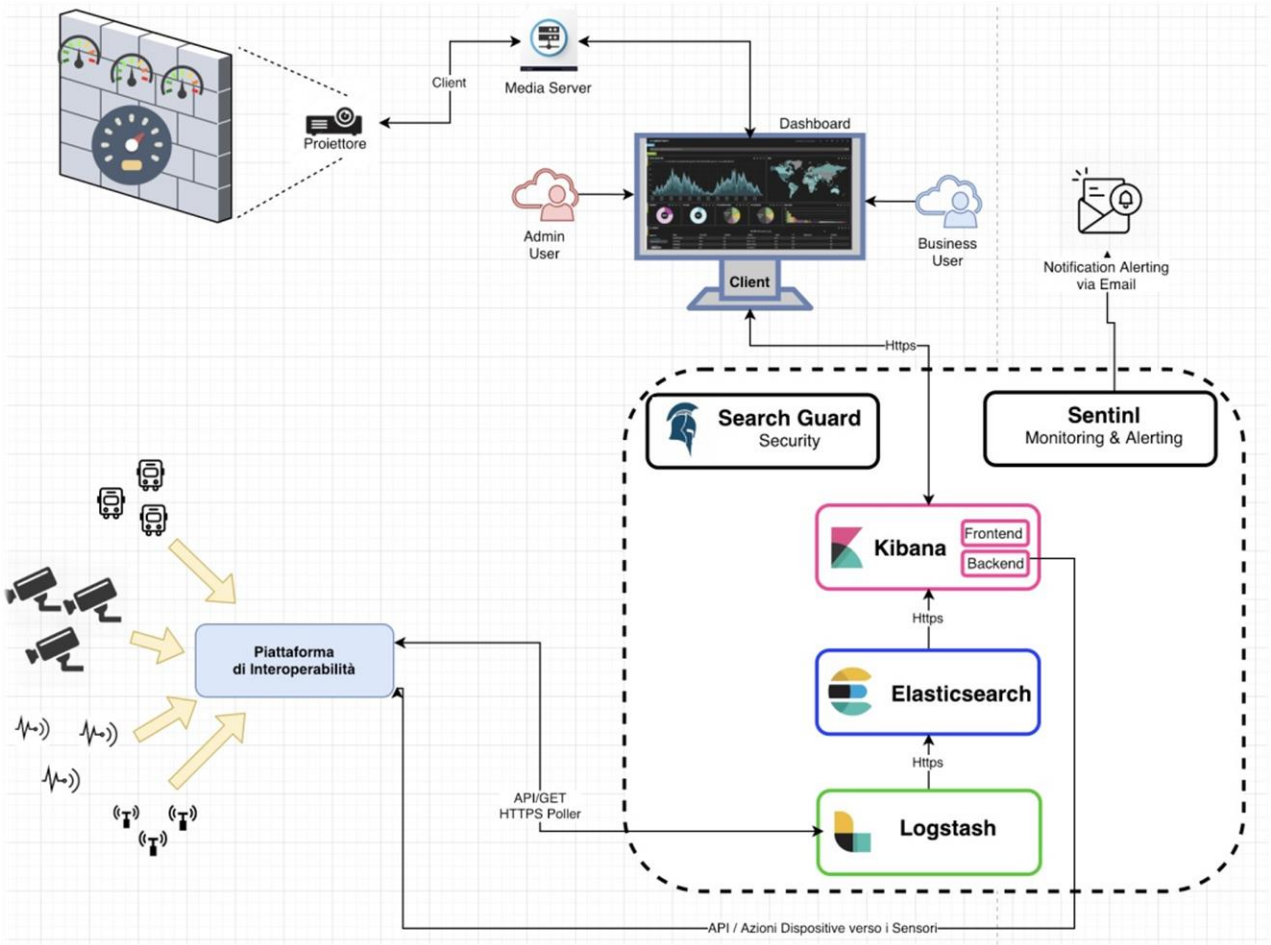
#SmartME services TOO(L) SMART

Budget: € 684,450.00

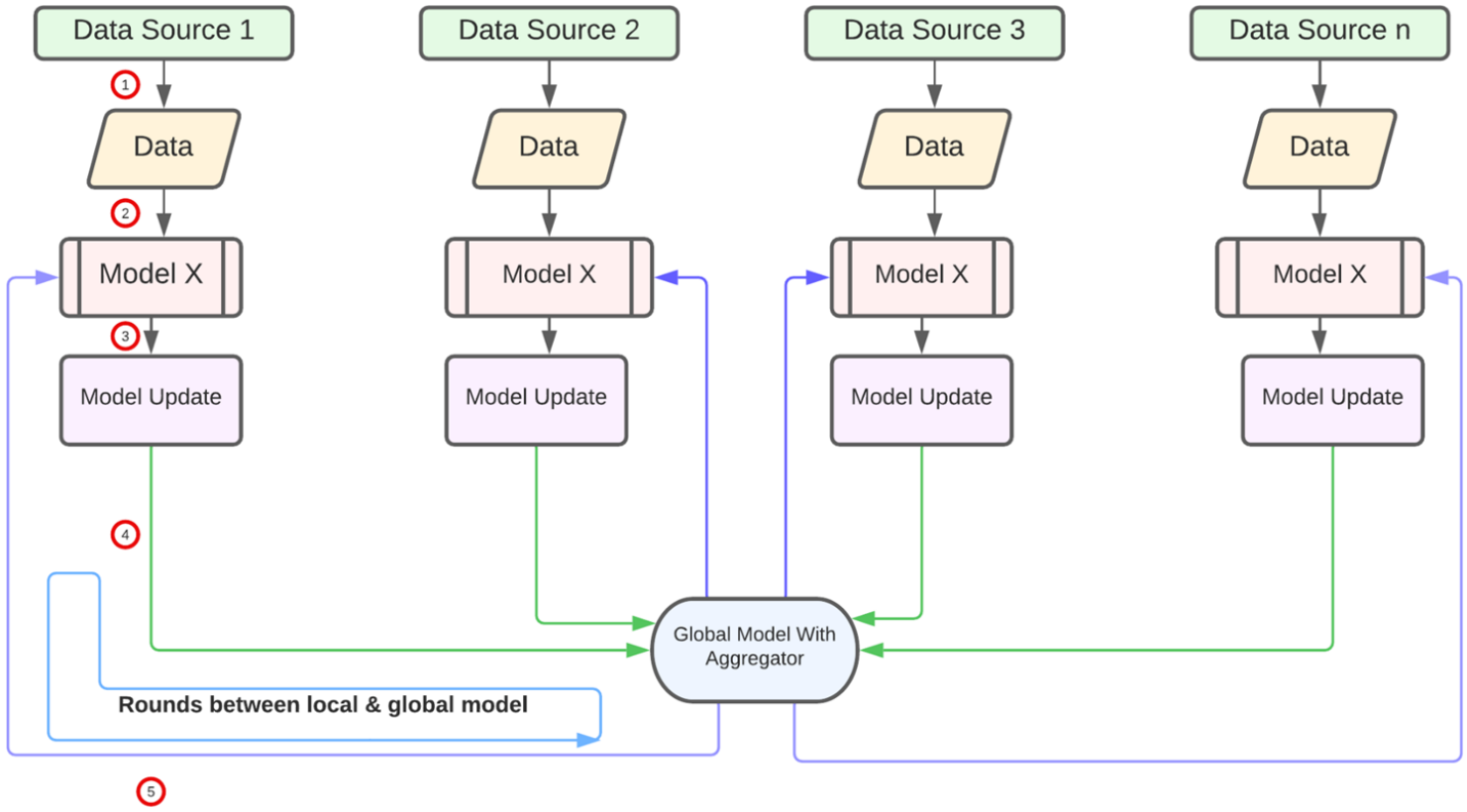
- CINI coordinates the dissemination of good practice at national level.
- Technical support is provided by the startup *smartme.IO*
- Evolution: Benevento, Montechiarugolo, Bari, Tangier

- TOO(L) smart is based on (and evolves) the #SmartMe IoT Platform
- #SmartME was born as a crowdfunding project for the construction of an infrastructure of smart services within the city of Messina.
- The basic technological requirements are based on the "open source" paradigm therefore, "open" solutions have been adopted for software, hardware and data.
- Stack4Things is the framework used for IoT devices management. it constitutes an evolution of OpenStack.
- The reference hardware adopted is based on the Arancino board, which integrates the Raspberry PI compute module and the Arduino control module in a single device.

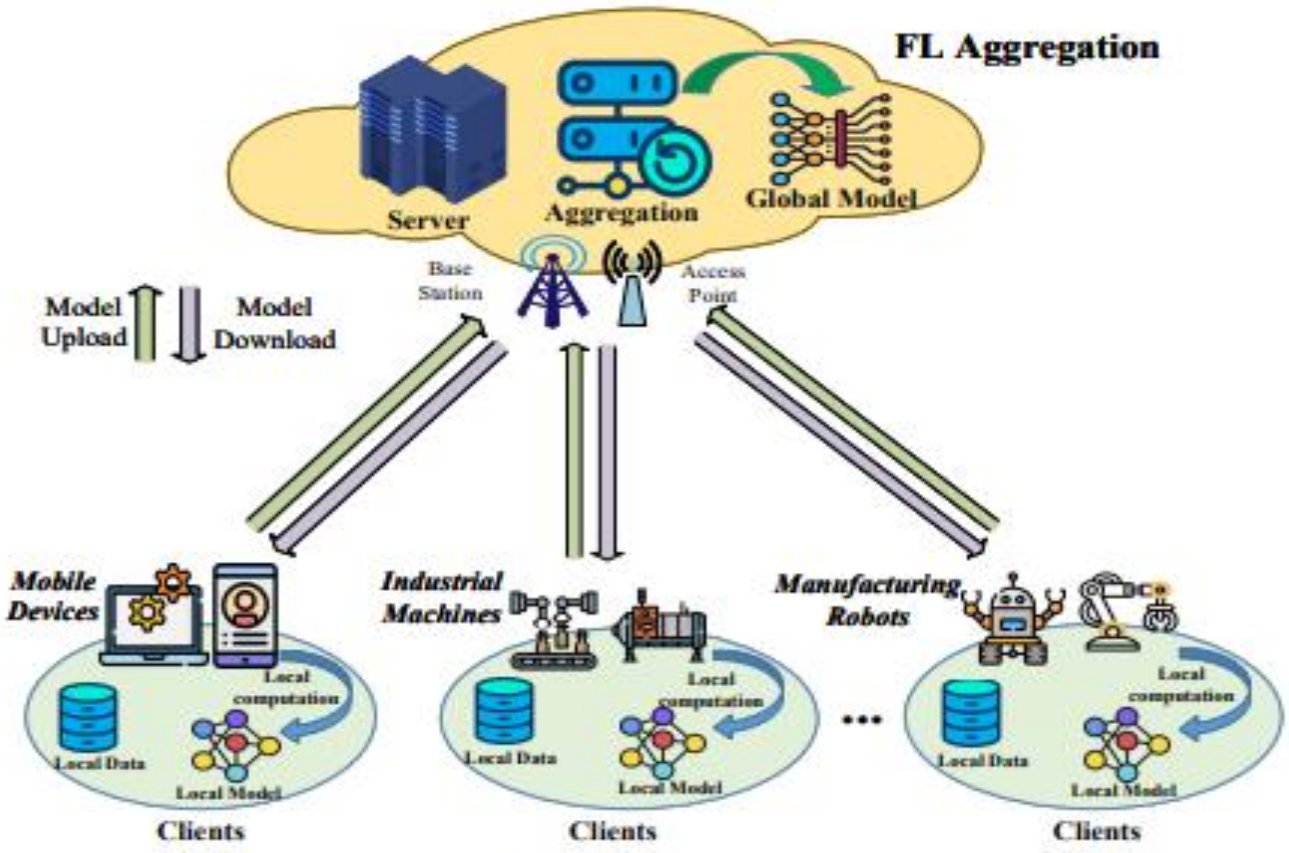
Lorenteggio area - Milan



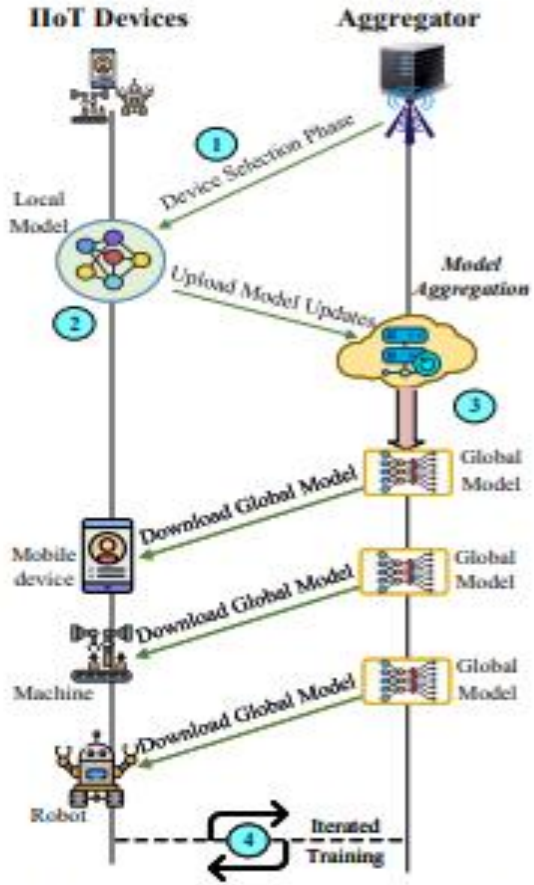
Federated Learning Architecture



Network Architecture and communication process for FL-IIoT



FL-IIoT Architecture



Communication in FL-IIoT

Federated Learning and IIoT: benefits

- ***Data Privacy Enhancement:*** protecting user information of FL is significant for building sustainable and safe IIoT systems.
- ***Improved Learning Quality:*** FL attracts large computation and dataset resources from a number of IIoT devices over the distributed IIoT network to train AI models. This cooperation would accelerate the convergence rate of the overall training process and improve learning accuracy.
- ***Low-latency Network Communication:*** by avoiding the offloading of huge data volumes to the server, FL can significantly reduce communication costs in intelligent IIoT networks, e.g., latency, consumed by raw data transmission

On-going activities

- Analysing the applicability of FL in *financial domain* like Insurance sector where risk is predicted without sharing the customer details to any central server.
- Analysing the applicability of FL in authentication where *biometric identification* is done in privacy preserving approach.
- Analysing the applicability of FL in developing the *network security* strategies.
- Prediction of various aspects like battery consumption, energy demand in *electric vehicle* in FL approach.

THANK YOU
FOR
YOUR ATTENTION

Antonio Puliafito
apuliafito65@gmail.com

Projects links:

- https://smartme.io
- https://arancino.cc
- https://git.openstack.org/cgit/openstack/iotronic