UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

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Architetture Big Data IOT 2019

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Paolo Nesi, paolo.nesi@unifi.it

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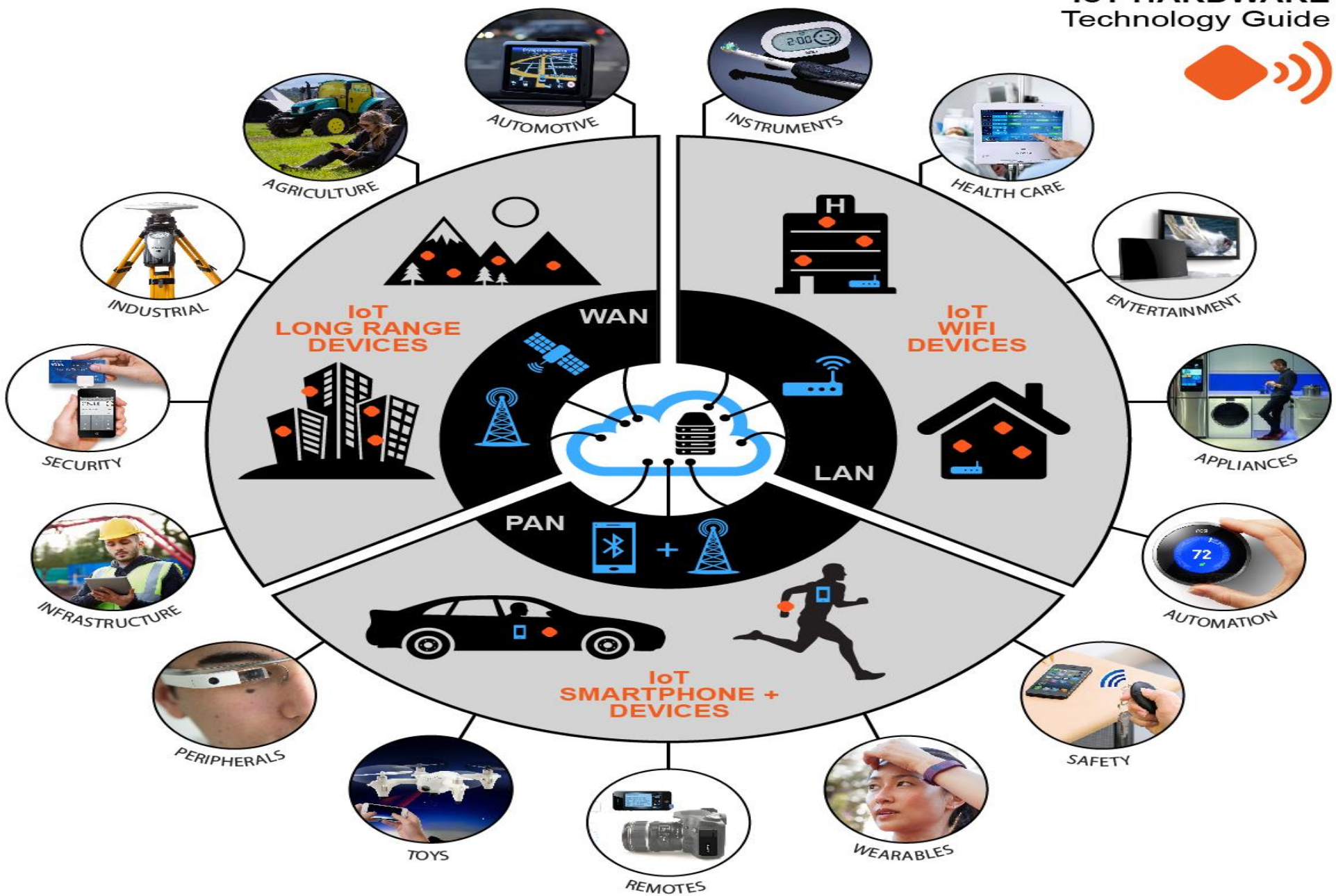
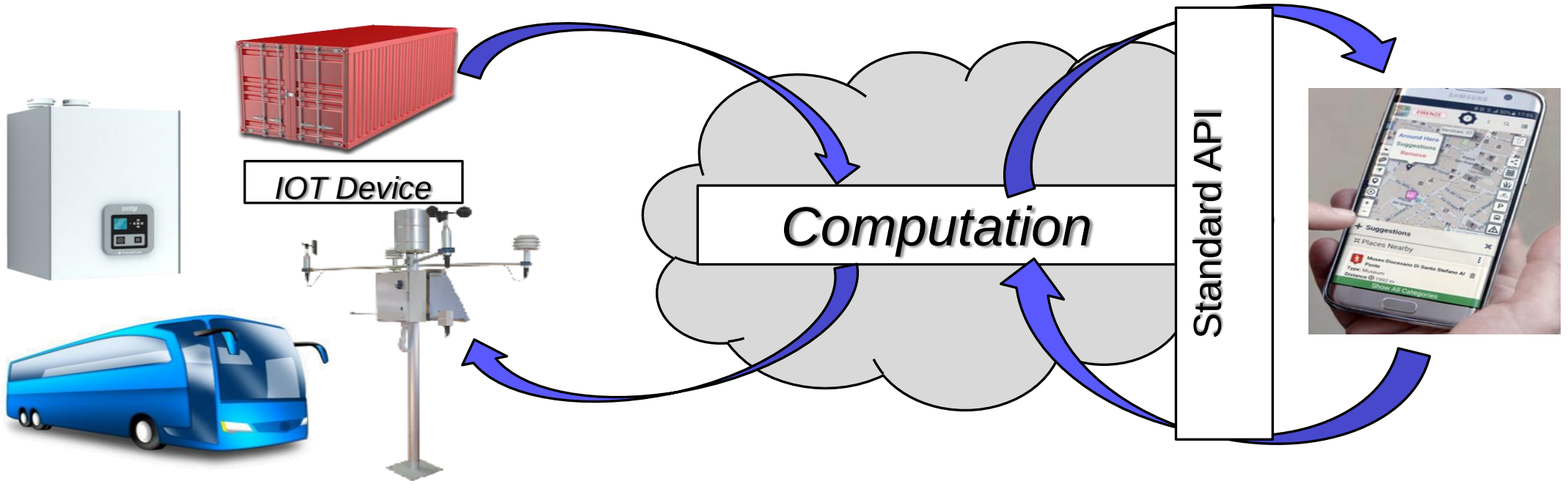

IoT HARDWARE
Technology Guide
AUTOMOTIVE
INSTRUMENTS
AGRICULTURE
HEALTH CARE
INDUSTRIAL
ENTERTAINMENT
SECURITY
APPLIANCES
INFRASTRUCTURE
AUTOMATION
PERIPHERALS
SAFETY
TOYS
REMOTES
WEARABLES
IoT
LONG RANGE
DEVICES
WAN
IoT
WIFI
DEVICES
LAN
PAN
IoT
SMARTPHONE +
DEVICES

IOT Solutions

IOT Main Concept

The implementation of smart services may implies the:

- acquisition of data from the field
- computation and imposition of actions/values
- Save of historical values, computer data analytics, etc.



IOT Main Concept

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- acquisition of data from the field
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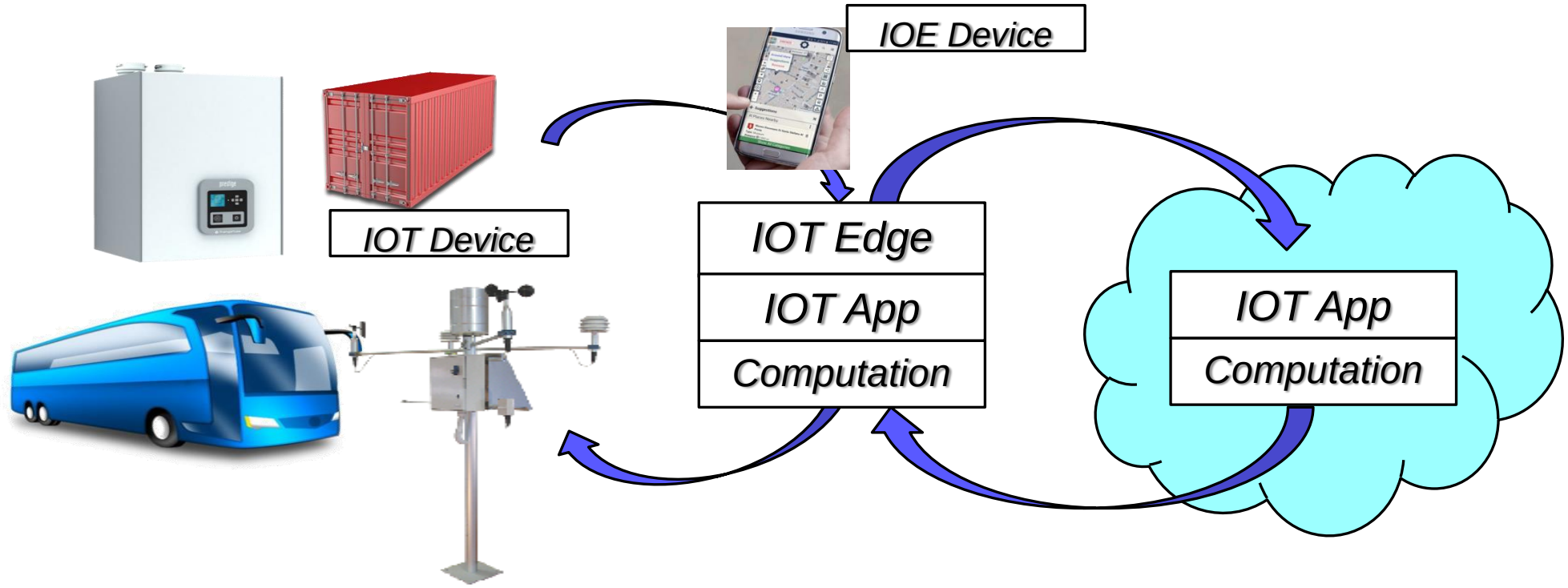
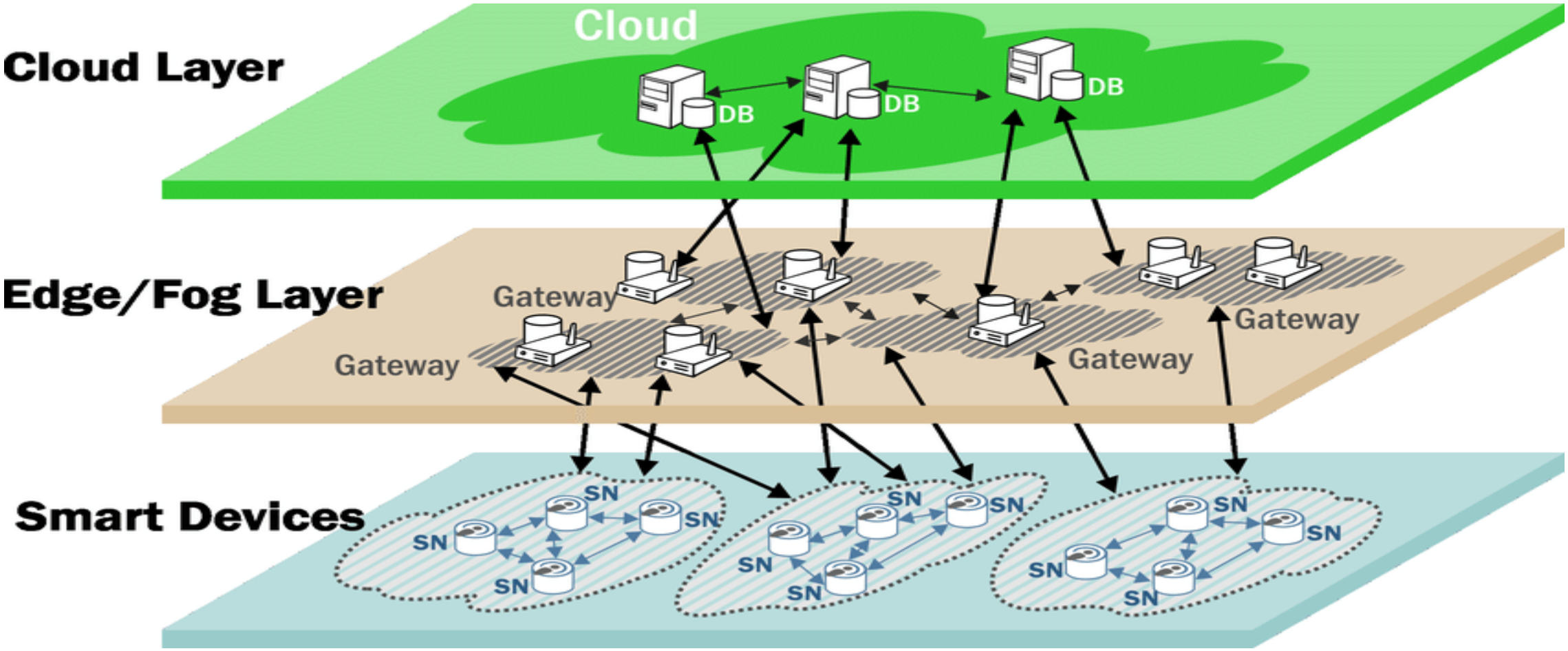
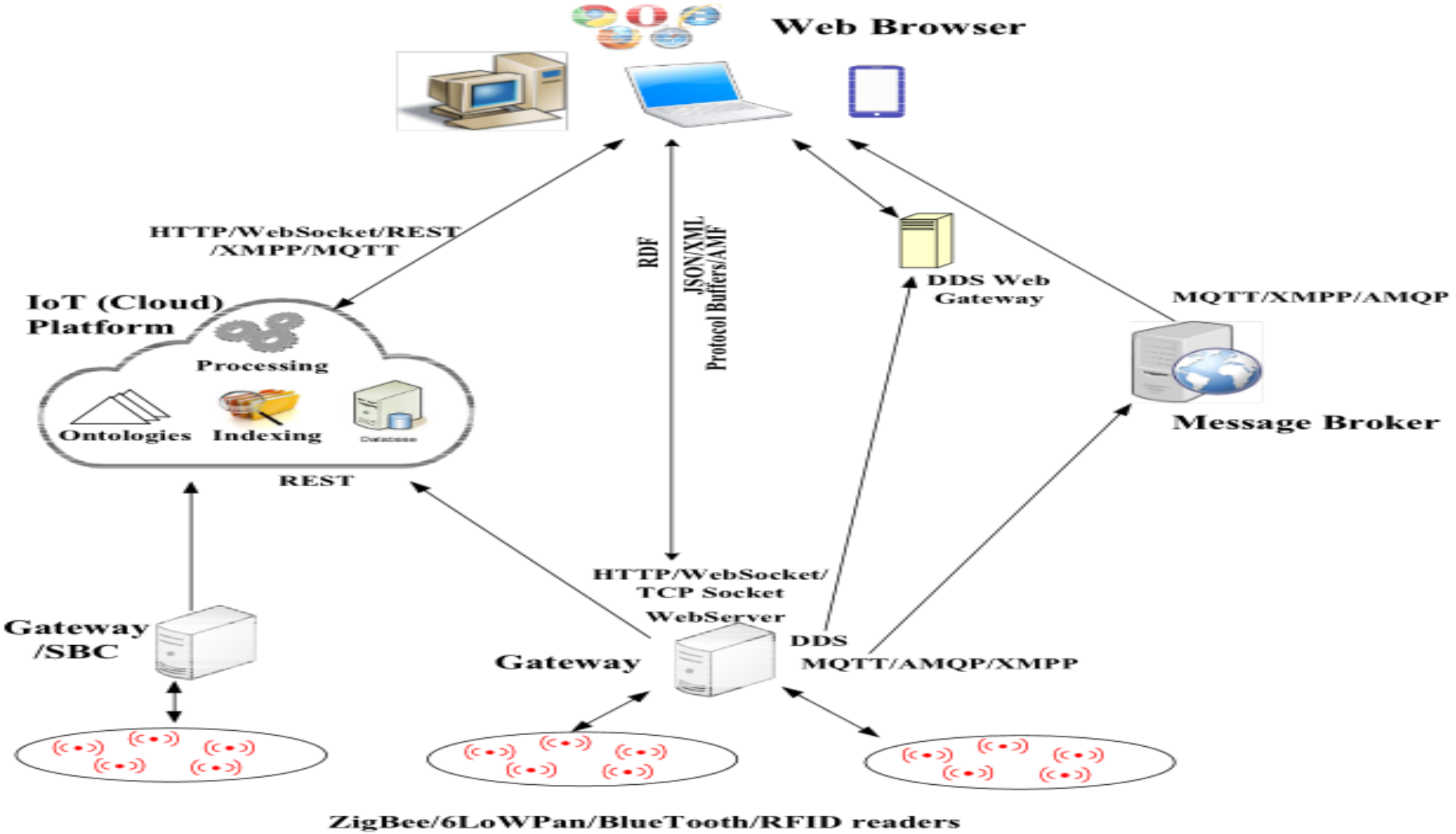
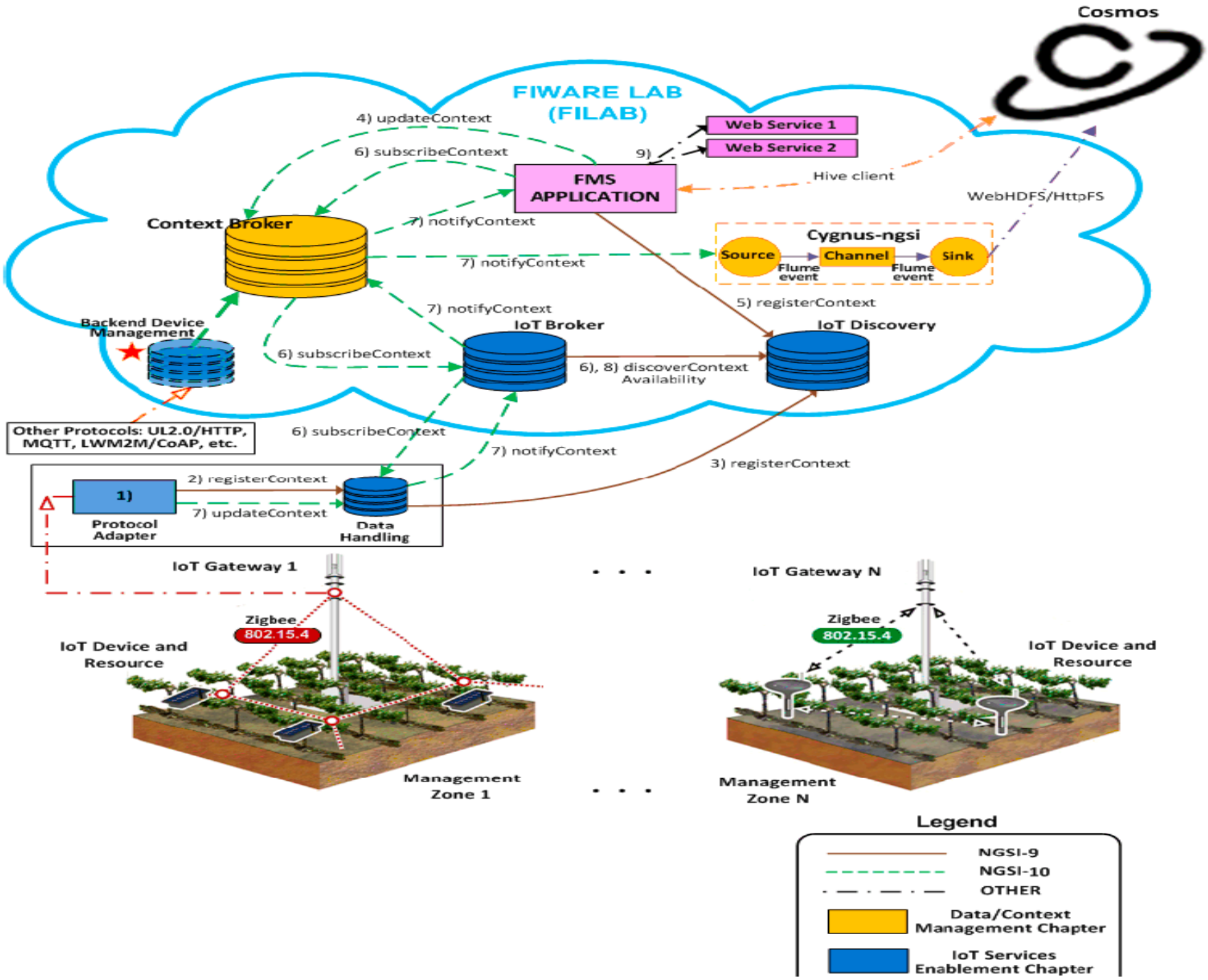


Cloud vs Fog/Edge Computing



Edge Computing, Fog Computing




Cosmos
FIWARE LAB (FILAB)
4) updateContext
6) subscribeContext
9)
Web Service 1
Web Service 2
FMS APPLICATION
Hive client
WebHDFS/HttpFS
Context Broker
7) notifyContext
Cygnus-ngsi
Source
Channel
Sink
Flume event
Flume event
5) registerContext
Backend Device Management
IoT Broker
IoT Discovery
6), 8) discoverContext Availability
Other Protocols: UL2.0/HTTP, MQTT, LWM2M/CoAP, etc.
2) registerContext
1)
7) updateContext
Protocol Adapter
Data Handling
3) registerContext
IoT Gateway 1
IoT Gateway N
Zigbee 802.15.4
IoT Device and Resource
Management Zone 1
Management Zone N
Legend
NGSI-9
NGSI-10
OTHER
Data/Context Management Chapter
IoT Services Enablement Chapter

IOT Context Broker

Context Broker operations: create & pull data

- **Context Producers** publish data/context elements by invoking the **update** operations on a Context Broker.
- **Context Consumers** can retrieve data/context elements by invoking the **query** operations on a Context Broker

Context Producer

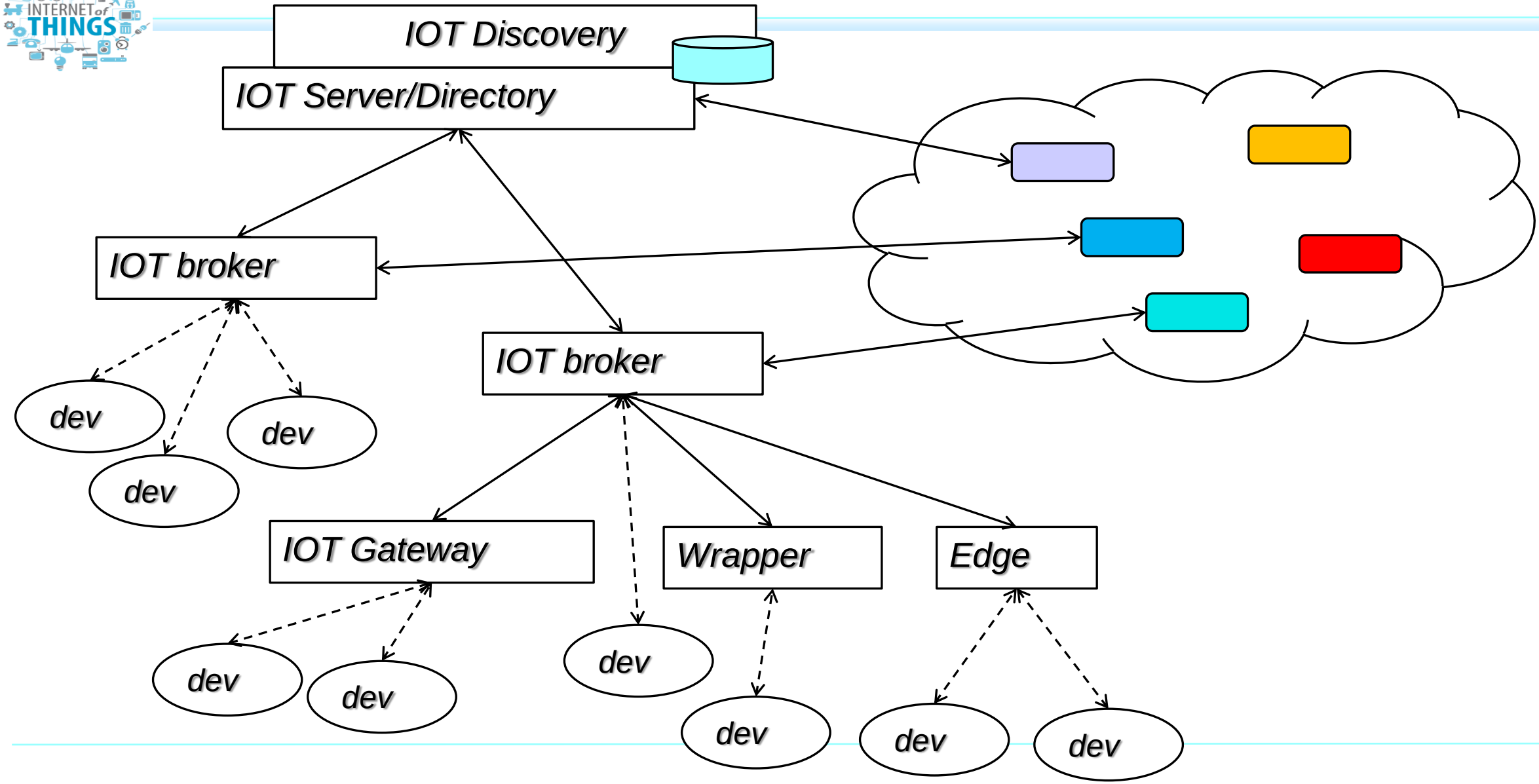
update

Context Broker

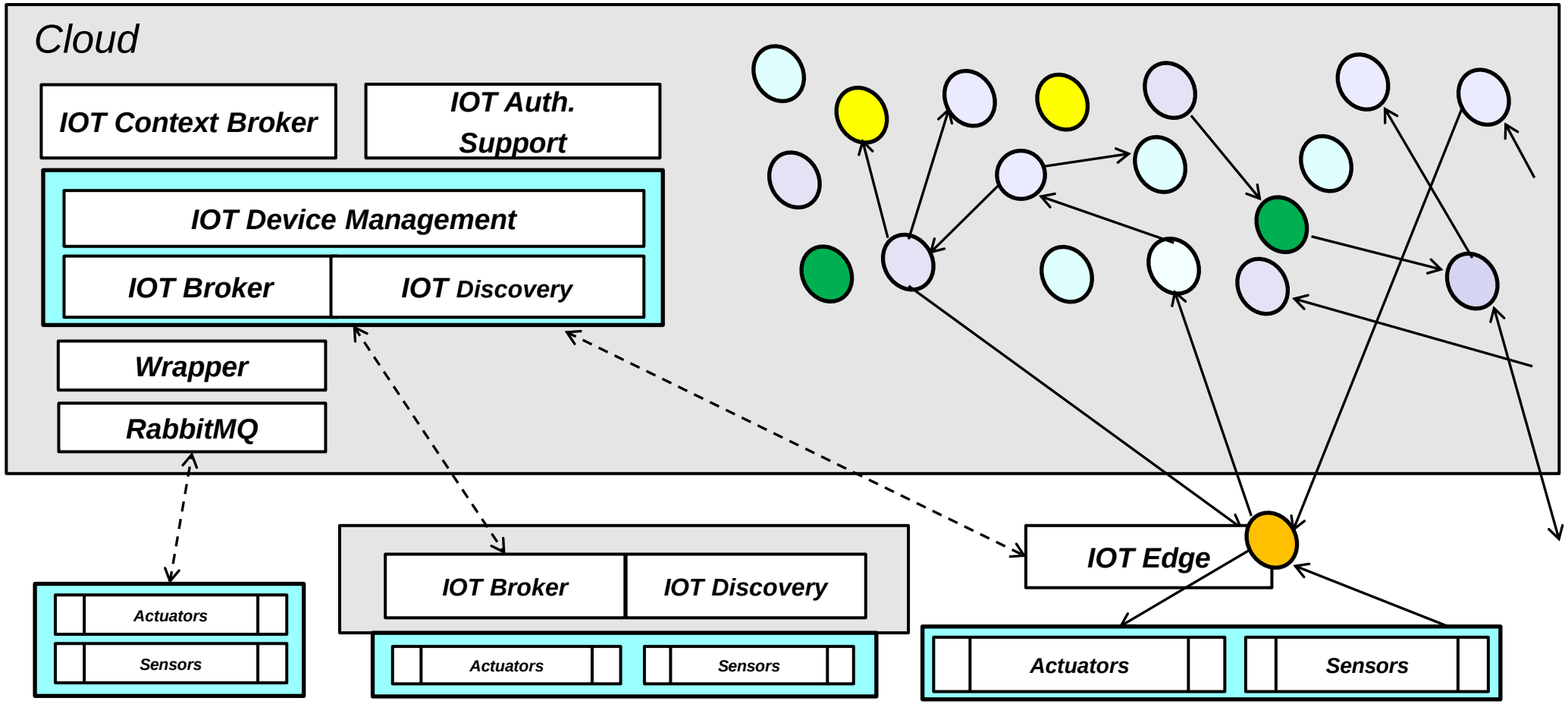
query

Context Consumer

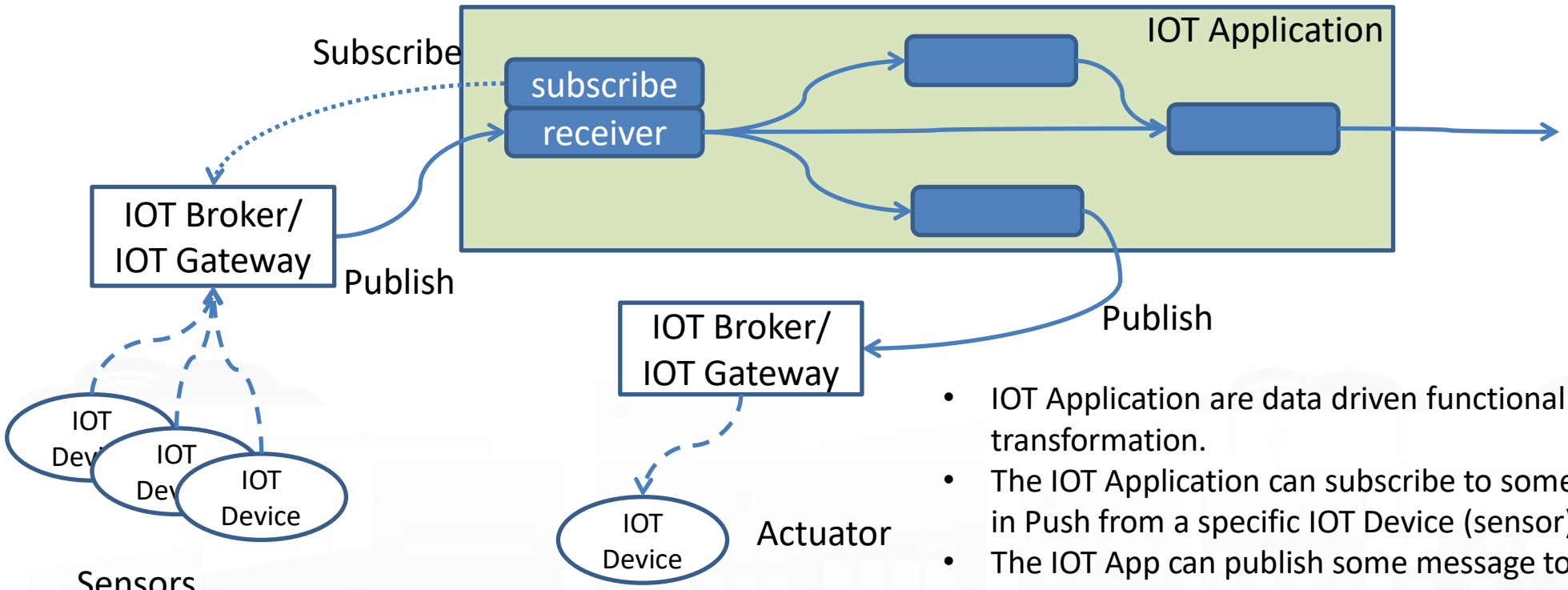
architettura



Conceptual architecture



IOT Basic



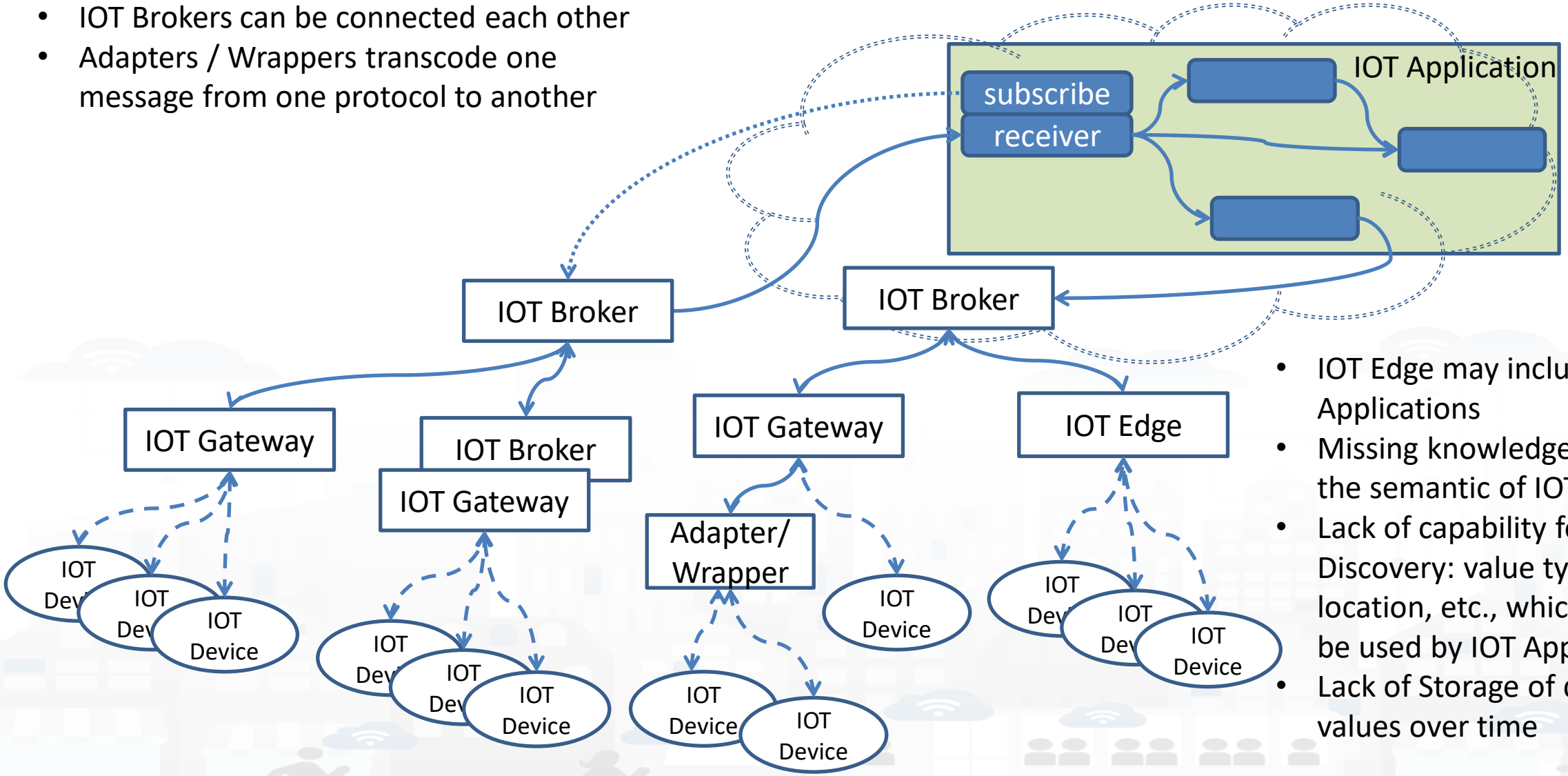
Sensors

- Sensors are programmed to send data (i) periodically, or (ii) when a relevant change occurs in the sensor value, or (iii) when events occur (for example a change of status of something), etc.
- Actuator perform some action on the field: change of status, reset, turn on something, change setting value, etc.

- IOT Application are data driven functional programs for data transformation.
- The IOT Application can subscribe to some IOT Brokers to receive data in Push from a specific IOT Device (sensor)
- The IOT App can publish some message toward some IOT Device (Actuator), passing via an IOT Broker.
- Continuous lines are messages via TCP/IP
- Dashed lines are message via some radio channel (Lora, BT, Wi-Fi, …)
- IOT Brokers and IOT Gateway can be distinct servers
- IOT Brokers can be on cloud
- IOT Gateway performs the SW update, the business management, access in Push and Pull

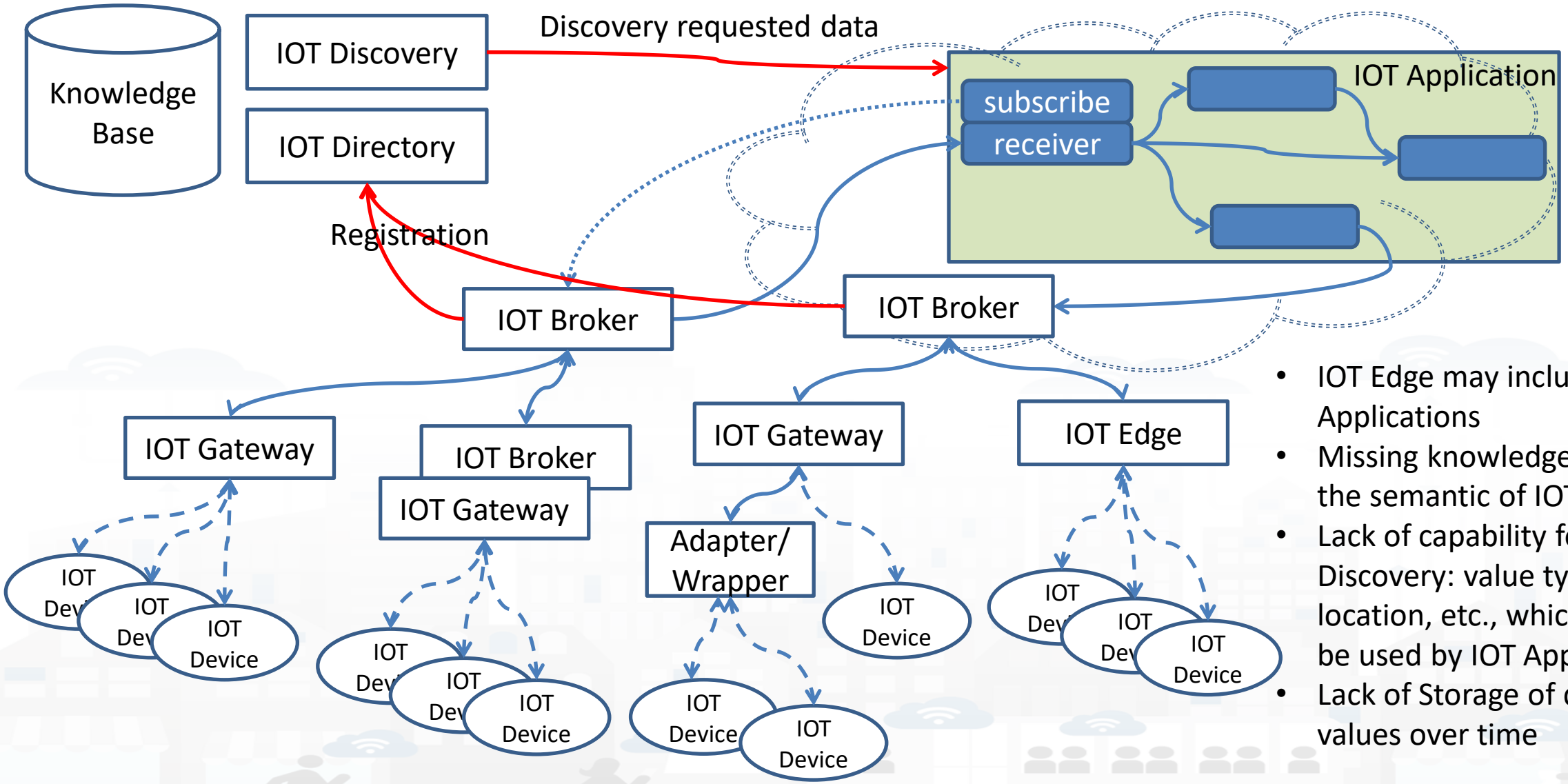
Definitions

- IOT Brokers can be connected each other
- Adapters / Wrappers transcode one message from one protocol to another



- IOT Edge may include IOT Applications
- Missing knowledge about the semantic of IOT devices
- Lack of capability for IOT Discovery: value type, location, etc., which could be used by IOT App
- Lack of Storage of data values over time

Definitions



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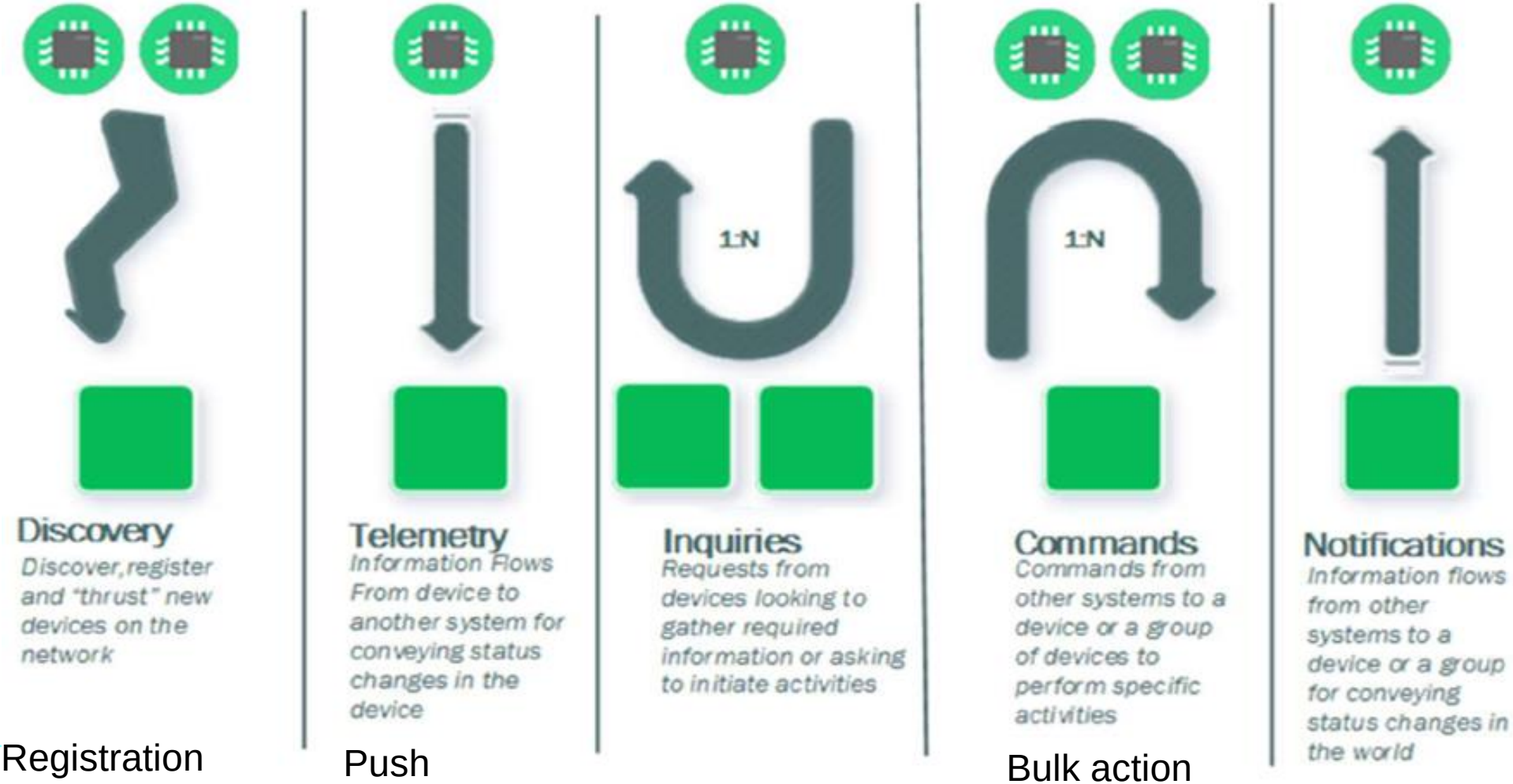
- Lack of Storage of data values over time

IOT/IOE Protocols

Communication Patterns



Registration

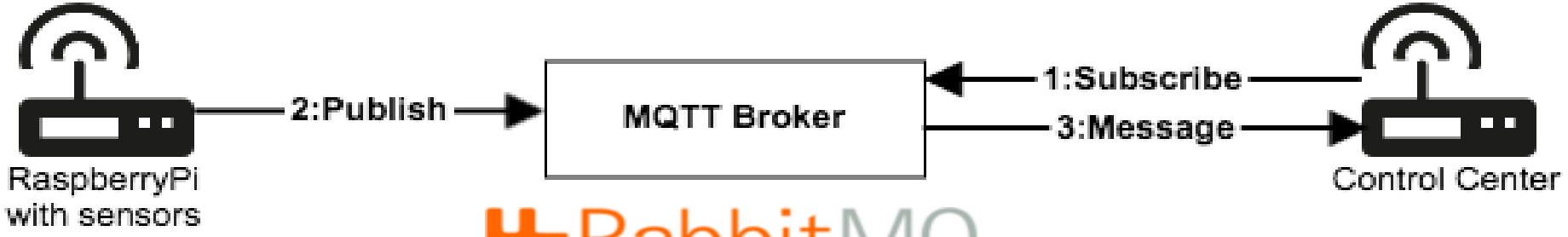
Push

Bulk action

- MQTT
- HTTP(s)
- AMQP
- COAP
- NGSI
- OneM2M
- WebSockets
- ……..
- Etc.

IOT Brokers

	AMQP	STOMP	JMS	COAP	NGSI	MQTT OASIS
RabbitMQ	X	X	X	X		X
Mosquitto						X
ActiveMQ	X	X	X			X
StormMQ	X					
HIVEMQ			X			X
ORION BROKER				X	X	X



RabbitMQ
Open Source Enterprise Messaging

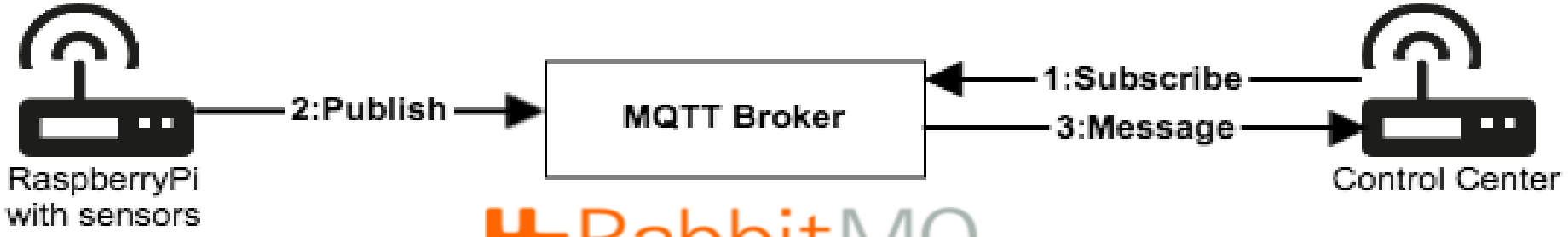
IOT stack protocols

Session		**MQTT, SMQTT, CoRE, DDS, AMQP , XMPP, CoAP, …**	**Security**	**Management**
Network	**Encapsulation**	**6LowPAN, 6TiSCH, 6Lo,** Thread, …	TCG, Oath 2.0, SMACK, SASL, ISASecure, ace, DTLS, Dice, …	**IEEE 1905, IEEE 1451,** …
	Routing	**RPL, CORPL, CARP, …**		
Datalink		WiFi, **Bluetooth Low Energy, Z-Wave, ZigBee Smart, DECT/ULE,** 3G/LTE, NFC, **Weightless, HomePlug GP, 802.11ah, 802.15.4e, G.9959, WirelessHART, DASH7,** ANT+, **LTE-A, LoRaWAN, …**		

https://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/

IOT Brokers

	AMQP	STOMP	JMS	COAP	NGSI	MQTT OASIS
RabbitMQ	X	X	X	X		X
Mosquitto						X
ActiveMQ	X	X	X			X
StormMQ	X					
HIVEMQ			X			X
ORION BROKER				X	X	X

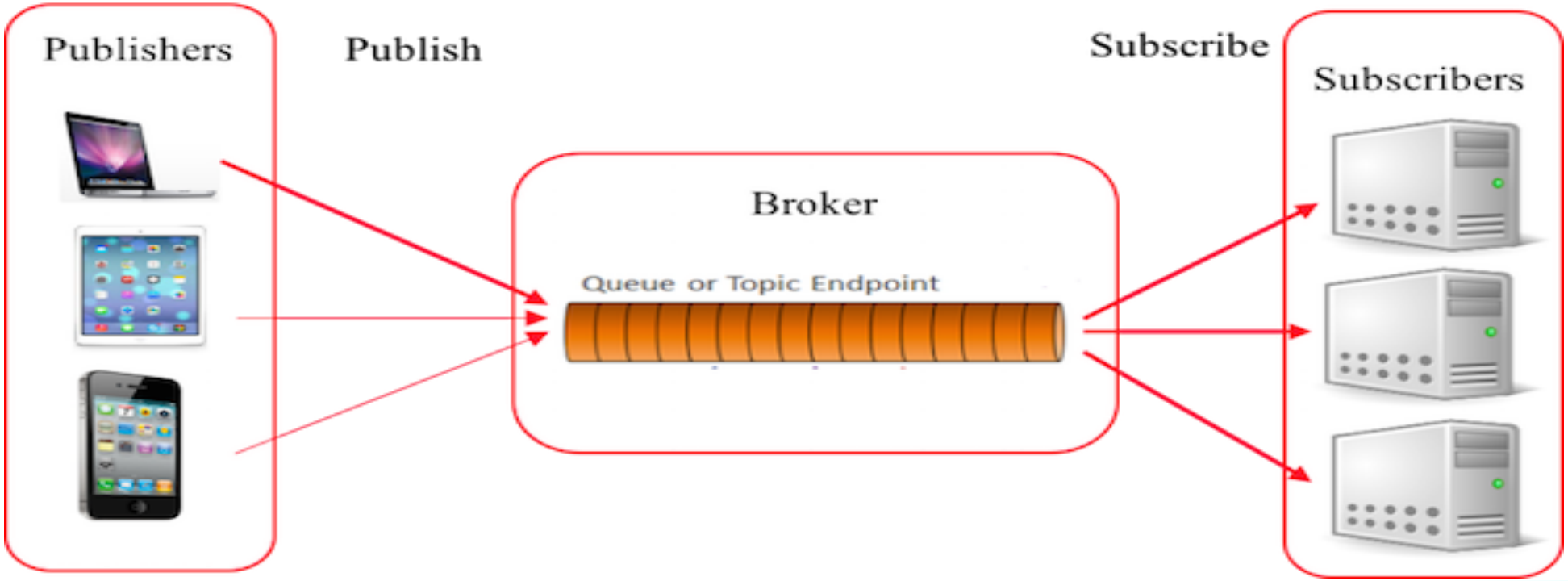


Comparison high level IOT protocols

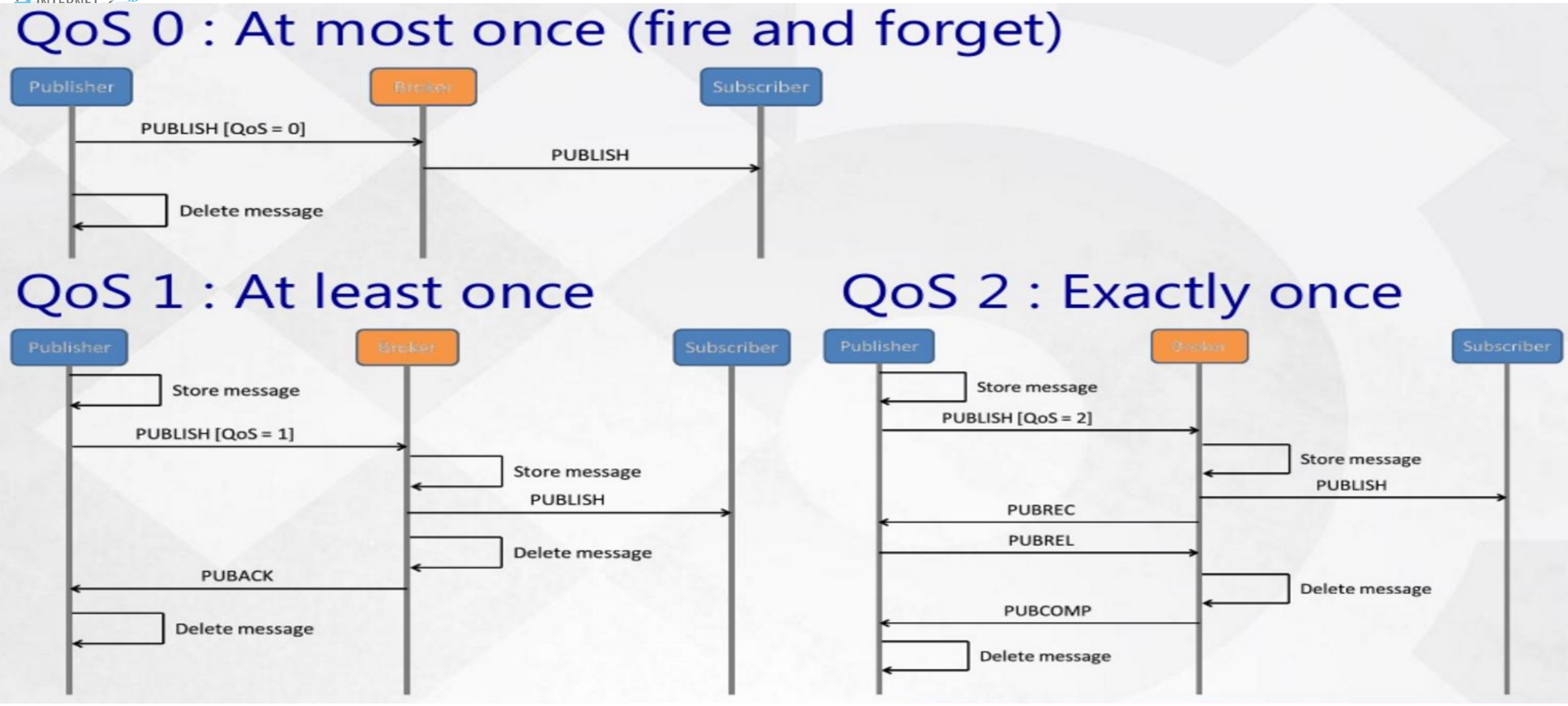
Protocols	UDP/TCP	Architecture	Security and QoS	Header Size (bytes)	Max Length(bytes)
MQTT	TCP	Pub/Sub	Both	2	5
AMQP	TCP	Pub/Sub	Both	8	-
CoAP	UDP	Req/Res	Both	4	20 (typical)
XMPP	TCP	Both	Security	-	-
DDS	TCP/UDP	Pub/Sub	QoS	-	-
NGSI	TCP/IP				

MQTT: Message Queue Telemetry Transport

- security obtained with SSL/TLS since it is over TCP
- ISO/IEC PRF 20922
- Over TCP/IP, Async, pub/subscribe,
- payload agnostic (can be encrypted)

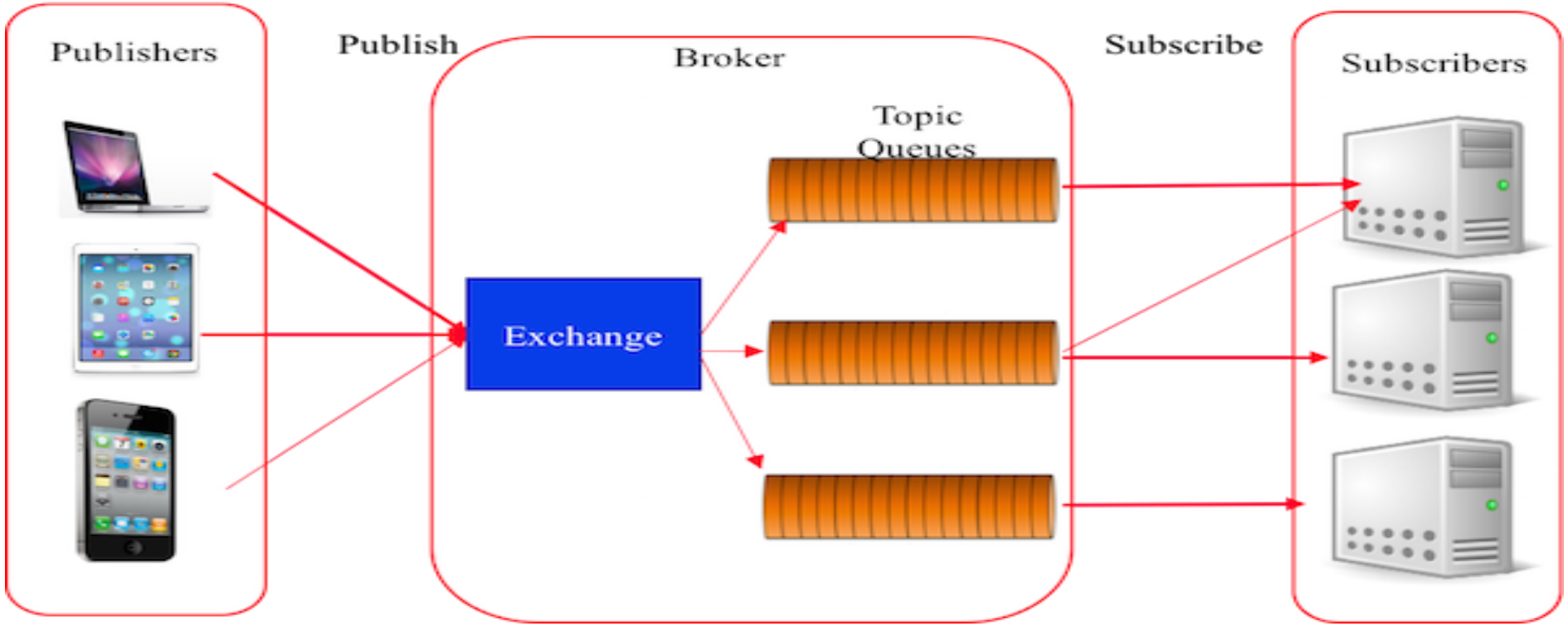


MQTT QoS


QoS 0 : At most once (fire and forget)
Publisher
Broker
Subscriber
PUBLISH [QoS = 0]
PUBLISH
Delete message
QoS 1 : At least once
Publisher
Broker
Subscriber
Store message
PUBLISH [QoS = 1]
Store message
PUBLISH
Delete message
PUBACK
Delete message
QoS 2 : Exactly once
Publisher
Broker
Subscriber
Store message
PUBLISH [QoS = 2]
Store message
PUBLISH
PUBREC
PUBREL
Delete message
PUBCOMP
Delete message

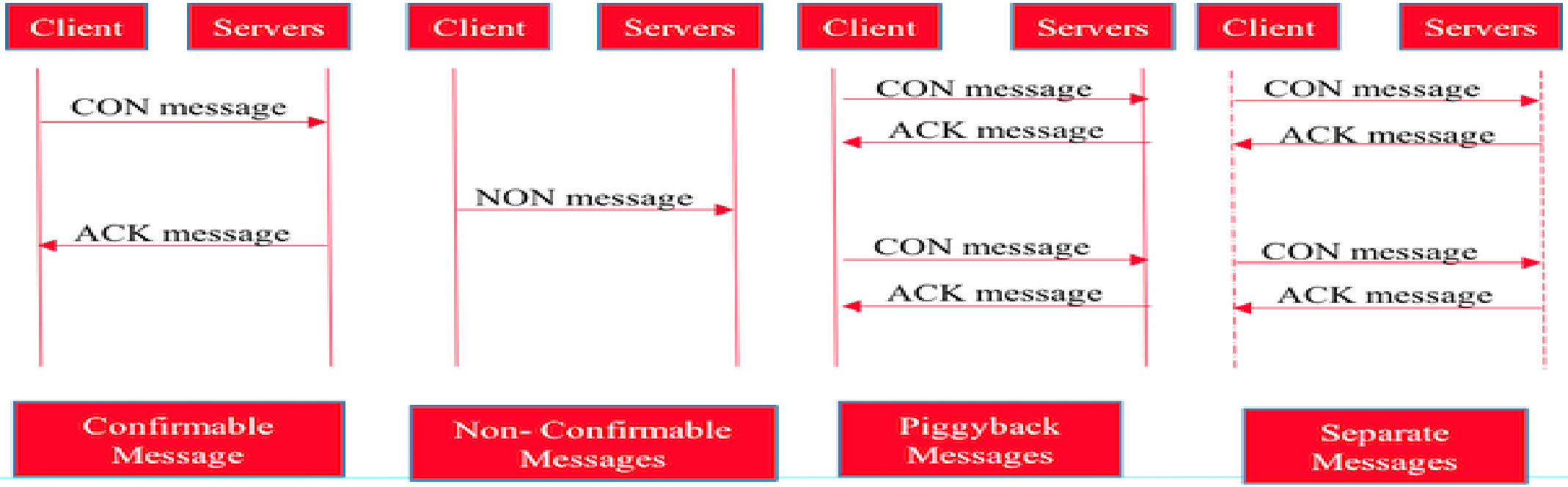
AMQP Advanced Message Queuing Protocol

- Over TCP, binary wire protocol
- Exchange decoupling



CoAP: Constrained Application Protocol

- OMA LWM2M over IETF CoAP (Internet Engineering Task Force)
- security obtained with DTLS, Datagram TLS
- HTTP like over UDP with fixed header, no TCP



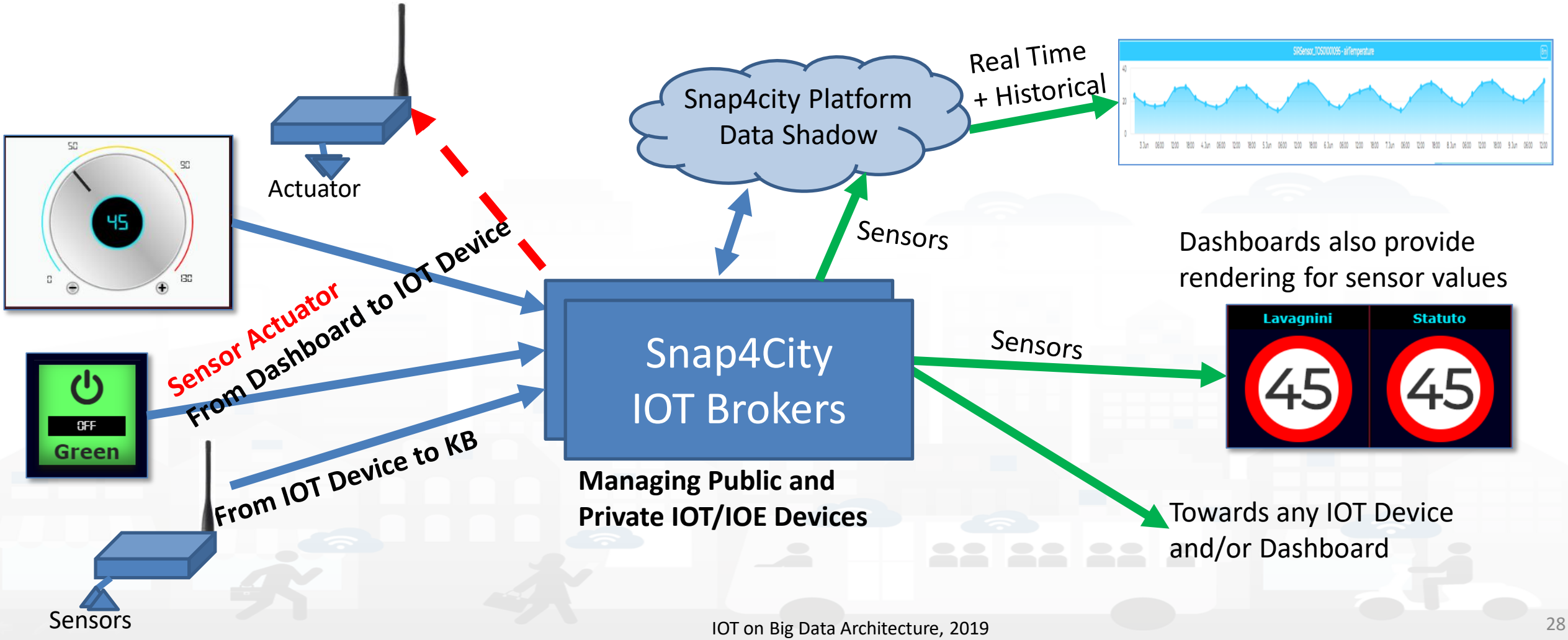
Other protocols

- **STOMP**: Streaming Text Oriented Messaging Protocol
  - Similar to HTTP
- **XMPP**: Extensible Messaging and Presence Protocol
  - Based on XML, proposed by IETF
  - Over TCP, can use HTTP
- **WAMP**: Web Application Messaging Protocol
  - WebSocket protocol by IANA
  - Over level 6
- **SNMP** by IETF, level 7
  - Over UDP, or IP
  - Monitoring status of servers
- **SigFOX**
- **OneM2M** AIOTI
  - a strategic enabler for IoT applications and companies developing IoT solutions

Comparison of lowlevel IOT prot.

Protocolli IoT	Standard	Frequenza	Range	Data Rates
Bluetooth	Bluetooth 4.2	2.4GHz (ISM)	50-150m (Smart/BLE)	1Mbps (Smart/BLE)
ZigBee	ZigBee 3.0 based on IEEE802.15.4	2.4GHz	10-100m	250kbps
6LoWPAN	RFC6282	(adapted and used over a variety of other networking media including Bluetooth Smart (2.4GHz) or ZigBee or low-power RF (sub-1GHz)	Vedi protocollo di supporto	Vedi protocollo di supporto
WiFi	Based on 802.11n (most common usage in homes today)	2.4GHz and 5GHz bands	Approximately 50m	600 Mbps maximum, but 150-200Mbps is more typical, depending on channel frequency used and number of antennas (latest 802.11-ac standard should offer 500Mbps to 1Gbps)
Cellular	GSM/GPRS/EDGE (2G), UMTS/HSPA (3G), LTE (4G)	900/1800/1900/2100MHz	35km max for GSM; 200km max for HSPA	(typical download): 35-170kps (GPRS), 120-384kbps (EDGE), 384Kbps-2Mbps (UMTS), 600kbps-10Mbps (HSPA), 3-10Mbps (LTE)
NFC	ISO/IEC 18000-3	13.56MHz (ISM)	10cm	100–420kbps
LoRaWAN	LoRaWAN	Various (europe, 868Mhz)	2-5km (urban environment), 15km (suburban environment)	0.3-50 kbps

IOT Data Driven

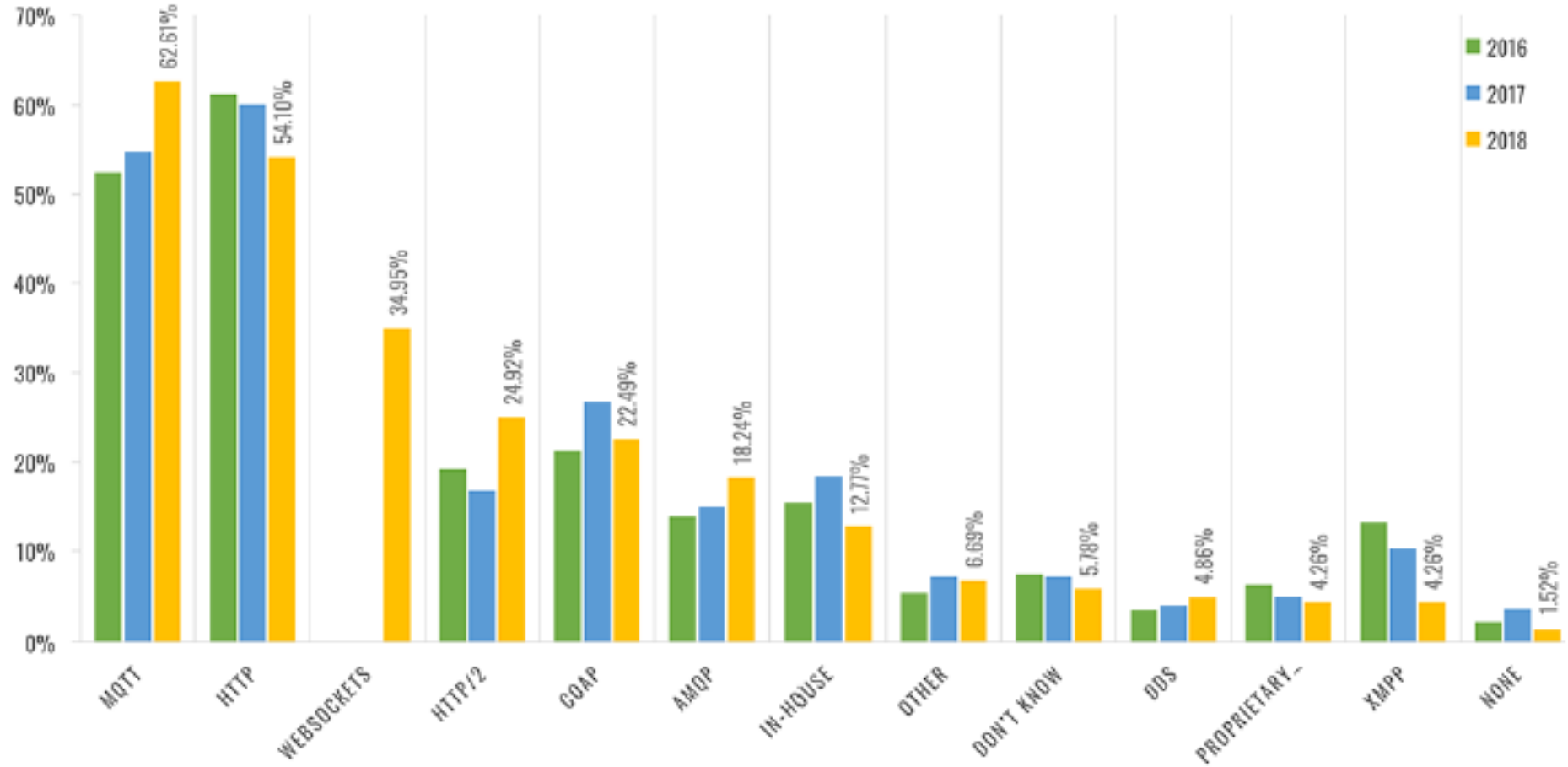


IOT Architectures Comparison

Market Solutions

	IOT Discovery Abstraction	Authentication, Authorization	Security end-2-end, secure on IOT and Dashboards	Open HW and Open SW	Integrated Community management	Data Types: IOT Devices, IOT App, Dashboard, Data	Data Type: Publish/share, Delegation, Consent and change	Data Type: Download and Delete	Auditing on Data Type Access	Open Source end-to-end	Scalability IOT	Visual Programming end-to-end applications	Advanced Smart City API, MicroServices	Multi Domain Semantic Platform	Standard based Modules and IOT, Open Devices	Resource Sharing	Data Analytics integrated	Dashboard H24/7, protected connection	Multi-protocol on IOT
		G				G	G	G	G										
Snap4City	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
KAA [53]	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	(Y)	N	N	Y	Y
Thingsboard [55]	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	Y	MQTT,coap, http
IOT eclipse.org [56]	N	N	N	(Y)	N	Y	N	N	N	Y	Y	N	N	N	Y	N	N	N	Y
IOT IGNITE [57]	N	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N	Y	MQTT
FIWARE [47]	N	Y	N	Y	N	N	N	Y	N	Y	(Y)	(N)	Y	N	Y	N	N	Y	Y
ARM mbed IoT [48]	Y	Y	Y	Y	Y	N	(N)	N	Y	Y	Y	N	N	N	Y	N	N	Y	Limited
Airvantage [51]	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	Y	MQTT, HTTP
AWS [43]	Y	Y	Y	Y	N	Y	(N)	Y	Y	N	Y	N	N	N	Y	Y	(Y)	Y	Limited
Azure IOT [44]	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y	Y	(Y)	Y	Limited
PTC ThingWorkx [59]	N	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	N	N	Y	N	N	Y	Y
Bosch IoT Suite [58]	Y	Y	Y	Y	Y	(Y)	(N)	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y
CISCO Jasper [55]	Y	Y	Y	Y	N	(Y)	(N)	N	Y	N	Y	N	N	N	N	--	(Y)	Y	N
Siemens MindSphere [60]	Y	Y	Y	(Y)	N	Y	(N)	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	Y
Carriots [54]	Y	Y	Y	(Y)	N	Y	N	N	Y	N	Y	N	N	N	--	N	N	Y	MQTT
Google IOT [45]	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	N	N	N	N	(Y)	(Y)	MQTT, HTTP
Homekit Apple [50]	Y	Y	Y	Y	N	Y	N	N	Y	N	(Y)	N	N	N	N	Y	N	Y	Limited
Smarthing Samsung [52]	Y	Y	Y	Y	Y	Y	(Y)	Y	Y	N	(Y)	N	N	N	N	N	N	Y	Limited

	Azure IoT	AWS	Google IoT
Data di rilascio (Out of beta)	Febbraio 2016	Dicembre 2015	Febbraio 2018
Quota di mercato	31.21%	51.82%	18.79%



	Azure IoT	AWS	Google IoT
Data di Rilascio (Out of Beta)	Febbraio 2016	Dicembre 2015	Febbraio 2018
Documentazione	Ottima	Molto Buona	Sufficiente
Certificazione	Ottenibile inviando l'applicazione sviluppata	Ottenibile sostenendo esami relativi a specifici ambiti	Ottenibile sostenendo esami relativi a specifici ambiti
Tipologia Certificazione	Non definita	Per specializzazione (Big Data, Security ecc) oppure per ruolo (Architect, Developer ecc)	Cloud Architect, Data Engineer, Suite Administrator
Vantaggi	Logo, crediti, sottoscrizioni, consulenze, accesso alla community ed eventi	Accesso alla community, logo, merchandise, accesso ad eventi	Non previsti

	Azure IoT	AWS	Google IoT
Architettura	Hub che comunica con tutti gli altri servizi.	I dati vengono raccolti dal Rules Engine e dal Device Shadows. A partire da questi si attivano i vari servizi.	Core che comunica con Funzioni, Pub/Sub e Dataflow. Questo si interfaccia agli altri servizi
API	REST	REST	REST
Protocolli	MQTT, AMQP, MQTT on WebSocket, AMQP on WebSocket, HTTPS, (1)	MQTT, MQTT on WebSocket, HTTPS	MQTT, HTTP
Sicurezza	TLS	TLS (mutual)	TLS
Autenticazione	SAS Token, IAM, x.509	x.509, IAM, Amazon Cognito, Federated, (2)	JSON Token, IAM, x.509
SDK	.NET, Java, Node.js, C, Python, (3)	C, Javascript, Java, Python, IOS, Android, Arduino Yun	Go, Java, .NET, Javascript, IOS, Android, PHP, Ruby, Python
Starter Kit	Intel. Raspberry Pi, Freescale, Texas Instruments, Seeed, resin.io, MinnowBoard, BeagleBoard	Broadcome, Marvell, Renesas, Texas Instruments, Intel, Microchip, Seeed, Mediatek, Qualcomm, BeagleBoard	Microchip, Adafruit, Marvell, TechNexion, Grove, Realtek, Allwinner, MangOH.

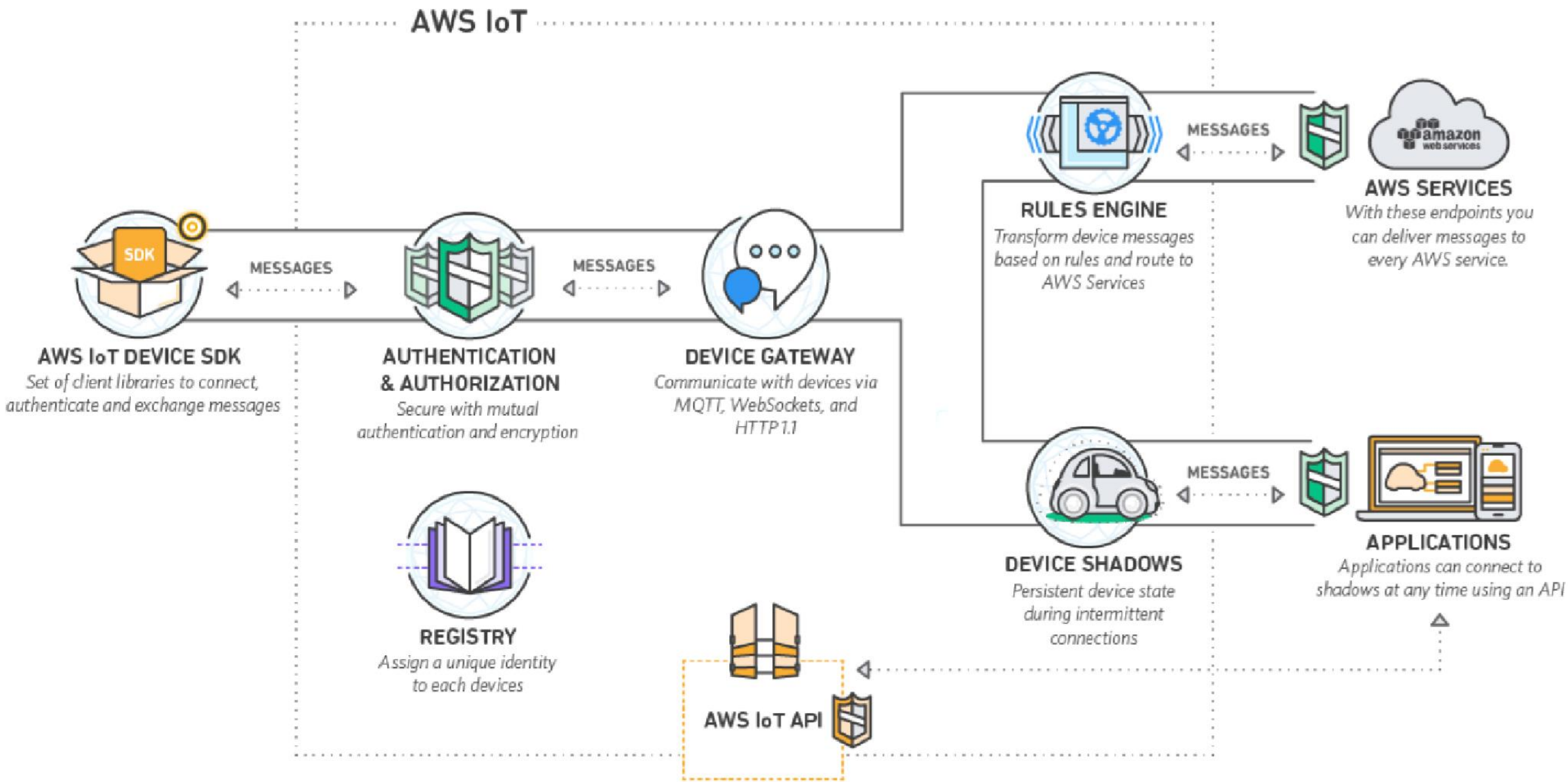
	Azure IoT	AWS	Google IoT
Edge			
Storage	Blob, CosmosDB, SQL		
Big Data			
Data Visualization	Power Bi		
Artificial Intelligence			
Intelligence API	Language, Speech, Vision, Knowledge		

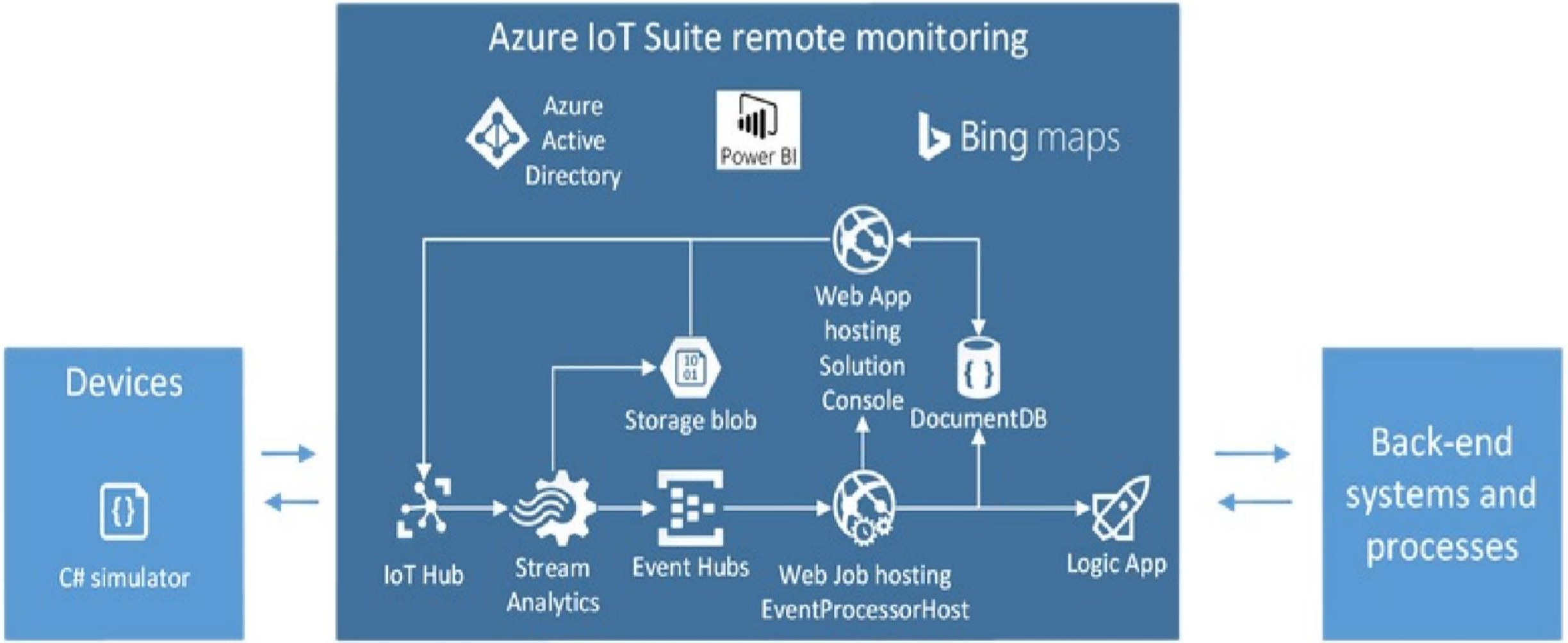
	Azure IoT	AWS	Google IoT
Prezzo	Diverse fasce di prezzo in base al numero di messaggi scambiati	Costo unitario per messaggio e per tempo di connessione del dispositivo	Costo basato sul volume di dati scambiati

	Azure IoT	AWS	Google IoT
Sicurezza	TLS	TLS (mutual)	TLS
Autenticazione	SAS Token, IAM, x.509	x.509, IAM, Amazon Cognito, Federated Identities	JSON Token, IAM, x.509

	Azure IoT	AWS	Google IoT
Protocolli	MQTT, AMQP, MQTT on WebSocket, HTTPS, AMQP on WebSocket	MQTT, MQTT on WebSocket, HTTPS	MQTT, HTTP
Communication Patterns	Telemetry, Query, Notification, Command	Telemetry, Query, Notification, Command	Telemetry, Query, Notification, Command

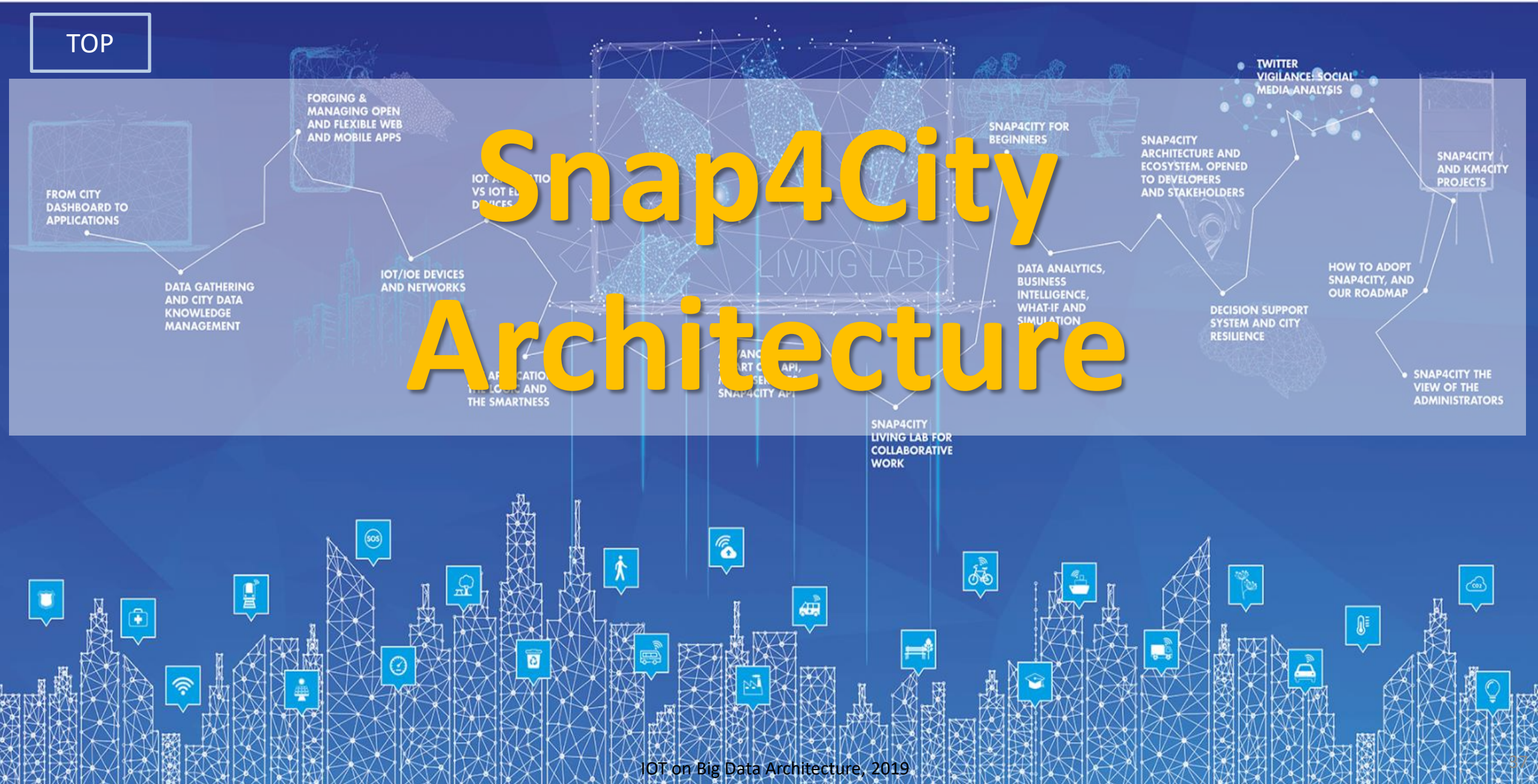
	Azure IoT	AWS	Google IoT
Scalability	Scaling da configurare mediante funzione	Servizio di scaling automatico	Servizio di scaling automatico
Rimborsi	10% di rimborso fino al 99%, al di sotto viene rimborsato il 25%	10% di rimborso fino al 99%, al di sotto viene rimborsato il 30%	10% di rimborso fino al 99%, nella fascia fino al 95% viene restituito il 25% e al di sotto di questa il 50%


AWS IoT
SDK
MESSAGES
MESSAGES
MESSAGES
MESSAGES
amazon web services
AWS IoT DEVICE SDK
Set of client libraries to connect, authenticate and exchange messages
AUTHENTICATION & AUTHORIZATION
Secure with mutual authentication and encryption
DEVICE GATEWAY
Communicate with devices via MQTT, WebSockets, and HTTP1.1
RULES ENGINE
Transform device messages based on rules and route to AWS Services
AWS SERVICES
With these endpoints you can deliver messages to every AWS service.
REGISTRY
Assign a unique identity to each devices
AWS IoT API
DEVICE SHADOWS
Persistent device state during intermittent connections
APPLICATIONS
Applications can connect to shadows at any time using an API


Azure IoT Suite remote monitoring
Azure Active Directory
Power BI
Bing maps
Web App hosting Solution Console
Storage blob
DocumentDB
Devices
C# simulator
IoT Hub
Stream Analytics
Event Hubs
Web Job hosting EventProcessorHost
Logic App
Back-end systems and processes

TOP

Snap4City Architecture



IOT on Big Data Architecture, 2019

URBAN PLATFORM: SMART CITY IOT AS A SERVICE AND ON PREMISE

100% OPEN SOURCE

APPLIANCES CONTAINERS

- LOCAL GOVERN
- STAKEHOLDERS
- CITY USERS
- IN-HOUSE
- ENERGY OPERATORS
- MOBILITY OPERATORS
- COMMERCIAL OPERATORS
- SECURITY OPERATORS
- INDUSTRIES
- RESEARCHERS
- START-UPS
- ASSOCIATIONS

- GDPR
- SECURITY
- PRIVACY
- ASSESSMENT
- AUDITING
- PENTESTED

- OPEN IOT DEVICES
- IOT EDGE
- IOT GATEWAY
- PAX COUNTERS
- IOT BUTTONS

- TEST CASES, SCENARIOUS, VIDEOS, HACKATHONS
- OPEN SOURCES, COMMUNITY OF CITIES
- TRAINING TUTORIALS, COMMUNITY MANAGEMENT

IOT APPLICATIONS - INSTANT APPS

DATA DRIVEN APPLICATIONS • REAL TIME PROCESSING • BATCH PROCESSING • ANY PROTOCOL & FORMAT

DASHBOARDS & APPLICATIONS

CONTROL ROOM • SITUATION ROOM • OPERATOR DASHBORDS • BUSINESS INTELLIGENCE • WHAT-IF ANALYSIS • DECISION SUPPORT • SIMULATIONS • RISK ANALYSIS • RESILIENCE ANALYSIS

MOBILE & WEB APPLICATIONS

DEVELOPMENT KIT • SUGGESTIONS • MOBILE APPS • MONITORING PANELS • PLATFORM UTILITIES • READY TO USE SMART APPLICATIONS

MICROSERVICES & ADVANCED SMART CITY API

LIVING LAB - DEV TOOLS - COWORKING

IOT DIRECTORY • SERVICE MAP • RESOURCE MANAGER • DATA GATE • R STUDIO • ETL

BIG DATA - DATA ANALYTICS

DATA ANALYTICS TOOLS - MICRO-APPLICATIONS

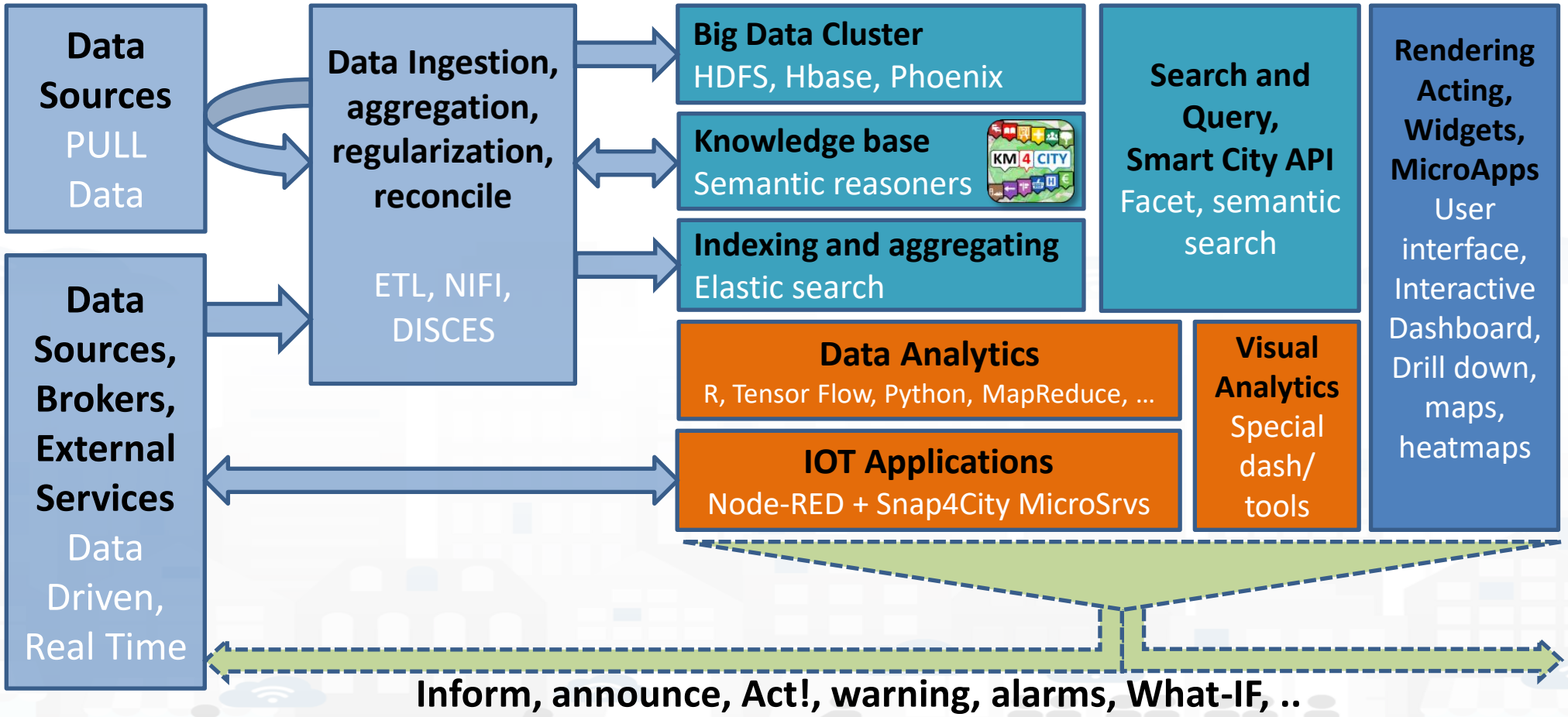
PREDICTIONS • ANOMALY DETECTION • WHAT-IF ANALYSIS • TRAFFIC FLOW RECONSTRUCTION • ORIGIN-DESTINATION MATRICES • SOCIAL MEDIA ANALYSIS • OFFER VS DEMAND ANALYSIS • ENVIRONMENTAL DATA ANALYSIS AND PREDICTIONS • REAL TIME HEATMAPS • ROUTING • ALERTING • EARLY WARNING • PERSONAL AND VIRTUAL ASSISSTANTS • SMART SOLUTIONS • SMART SHARING • PARTECIPATORY

KM4CITY DATA AGGREGAT KNOWLEDGE BASE - EXPERT SYSTEM OF THE CITY – BIG DATA STORE

IOT MNG - DATA MNG - DATA INSPECTOR – PROCESS MNG – USER ENGAGEMENT – GDPR MNG ...

GIS	CITY UTILITIES	OPEN DATA	LEGACY & EXTERNAL SERVICES	PERSONAL DATA	IOT / IOE	BROKERS	KPI	INDUSTRY 4.0	SOCIAL MEDIA

Snap4City as a Lambda Architecture



Snap4Industry as a Lambda Architecture

Data Sources PULL Data

Data Sources, Brokers, External Services Data Driven, Real Time

Data Ingestion, aggregation, regularization, reconcile

ETL, NIFI, DISCES

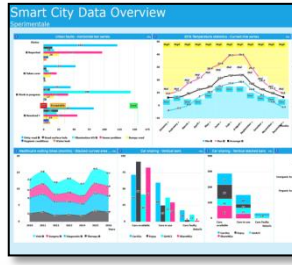
Big Data Cluster
HDFS, Hbase, Phoenix

Knowledge base
Semantic reasoners

Indexing and aggregating
Elastic search

Search and Query, Smart API
Facet, semantic search

Rendering Acting, Widgets, MicroApps
User interface, Interactive Dashboard, Drill down, maps, heatmaps



Data Analytics
R, Tensor Flow, Python, MapReduce, …

IOT Applications
Node-RED + Snap4City MicroSrvs

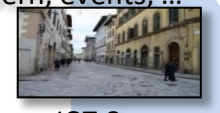
Visual Analytics
Special dash/ tools

Inform, announce, Act!, warning, alarms, What-IF, ..

Smart City Functional Architecture

Transport systems Mobility, parking

Public Services, Govern, events, …



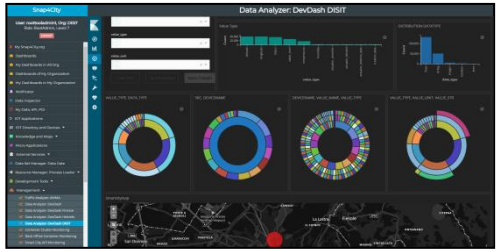
Sensors, IOT Cameras, Wi-Fi

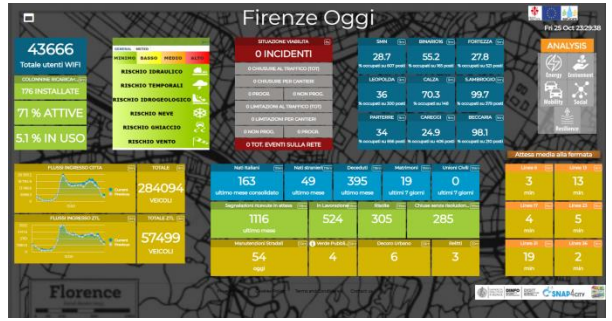
Environment, Water, energy

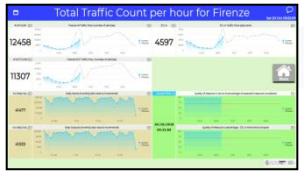
Shops, services, operators

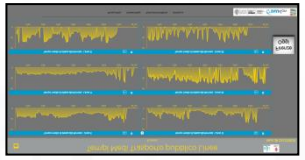
Social Media

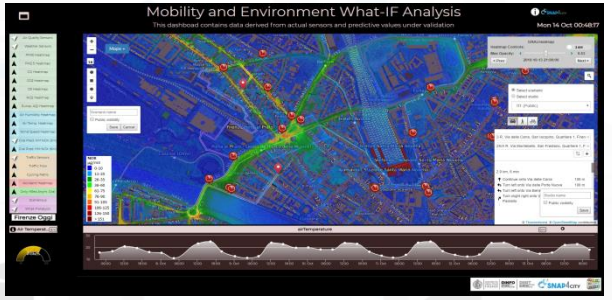
Social Media Crawler and Manager











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Search and Query, Smart City API Facet, semantic search

Visual Analytics Special dash/ tools

Rendering Acting, Widgets, MicroApps User interface, Interactive Dashboard, Drill down, maps, heatmaps

Inform, announce, Act!, warning, alarms, What-IF, ..

LOGIN

Dashboards (Public)

Knowledge and Maps

- Service Map (Toscana)
- Service Map 3D (Firenze)
- Helsinki Service Map
- Garda Lake Service Map
- Cagliari Service Map
- Service Map 3D (Helsinki)

Micro Applications

External Services

Data Set Manager: Data Gate

Resource Manager

Development Tools

Management

Help and Contacts

Documentation and Articles

Km4City portal

DISIT Lab portal

Home / Snap4City - scalable Smart aNalytic APplication builder for sentient Cities

Snap4City - scalable Smart aNalytic APplication builder for sentient Cities

Tutorials | Scenarious | Innovations | Interoperability | Installations | What People say

Mobile Apps | IOT Devices | IOT Applications | Data Analytics | Dashboards | Living Lab | Smart City API

Smart City Ontology | Articles

SMARTCITY EXPO WORLD CONGRESS 19-21 Nov. 2019 *See you at Stand A118*

SNAP4CITY on EUROPEAN OPEN SCIENCE CLOUD MARKETPLACE

SNAP4CITY HACKATHON BUILD YOUR APP FOR A CONNECTED CITY

Smart Cities need to set up a flexible Living Lab to cope with the city evolution in terms of services and city users' needs and sustainability. Snap4City solution (https://www.snap4city.org) provides a flexible method and solution to quickly create a large range of smart city applications exploiting heterogeneous data and enabling services for stakeholders by IOT/IOE, data analytics and big data technologies. Snap4City applications may exploit multiple paradigms as data driven, stream and batch processing, putting co-creation tools in the hands of: (i) Smart Living Lab users and developers a plethora of solutions to develop applications without vendor lock-in nor technology lock-in, (ii) final users customizable / flexible mobile Apps and tools, (iii) city operators and decision makers specialized / sophisticated city dashboards and IOT/IOE applications for city status monitoring, control and decision support. Snap4City satisfies all the expected requirements of Select4Cities challenge PCP and much more, and it is 100% open source, scalable, robust, respects user needs and privacy; provides MicroServices and easily replaceable tools; compliant with GDPR; provides a set of tools for knowledge and living lab management, and it is compliant

Login

Registration

- New Registration
- Request a new password

Search

Search

-Any-

Training Snap4City from Data to Sentient Cities in a Snap

Program and Interactive Slides

Powered by www.km4city.org

FI-WARE Node-RED

Virtual Assistant

IOT Device Registration

Standards and Interoperability

Compliant with: AMQP, COAP, MQTT, OneM2M, HTTP, HTTPS, TLS, Rest Call, SMTP, TCP, UDP, NGSI, LoraWan, TheThingsNetwork, SigFOX, DATEX II, SOAP, WSDL, Twitter, FaceBook, Telegram, SMS, OLAP, MySQL, Mongo, HBASE, SOLR, SPARQL, EMAIL, FTP, FTPS, WebSocket, WebSocket Secure, ModBUS, OPC, GML, RS485, WFS, WMS, ODBC, JDBC, Elastic Search, Phoenix, XML, JSON, CSV, db, GeoJSON, Enfuser FMI, Android, Raspberry Pi, Local File System, ESP32, Libelium, IBIMET, OBD2, SVG, XLS, XLSX, TXT, HTML, CSS, etc.

Level 3 user: add personal devices and create Dash

- With Smart city data and information +
- Personal IOT/IOE, which can be registered and created

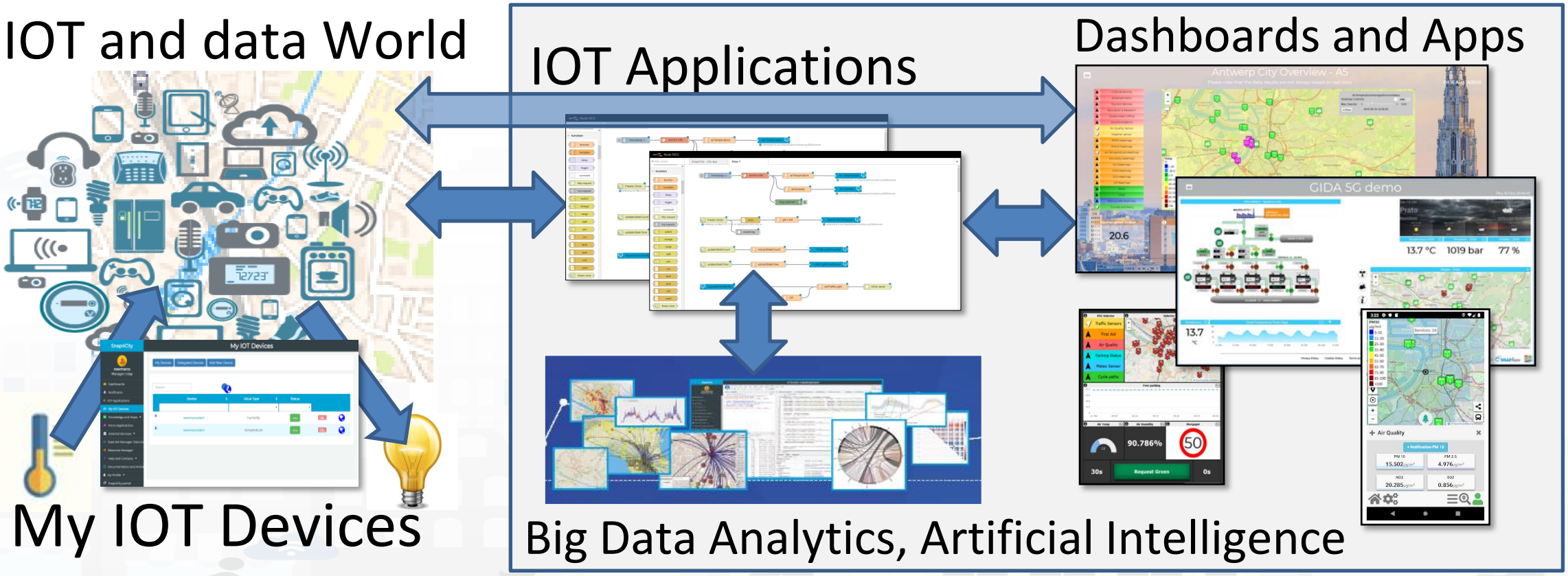
IOT and City data World

My Dashboard

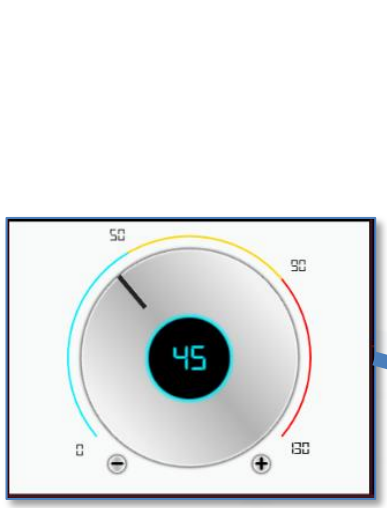
Registration of My IOT Devices

Sentient Solutions

Dashboards with data driven IOT Applications enforcing intelligence



IOT Data Driven



Actuator

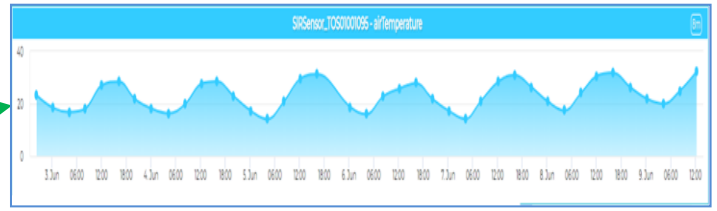
Sensor Actuator
From Dashboard to IOT Device

From IOT Device to KB

Sensors

Snap4city Platform
Data Shadow

Real Time
+ Historical



Sensors

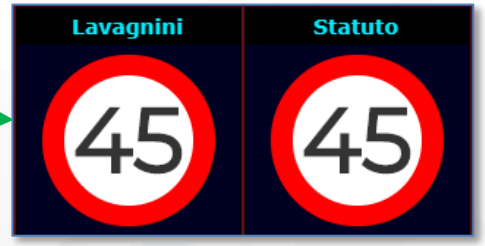
Snap4City
IOT Brokers

Managing Public and Private IOT/IOE Devices

Sensors

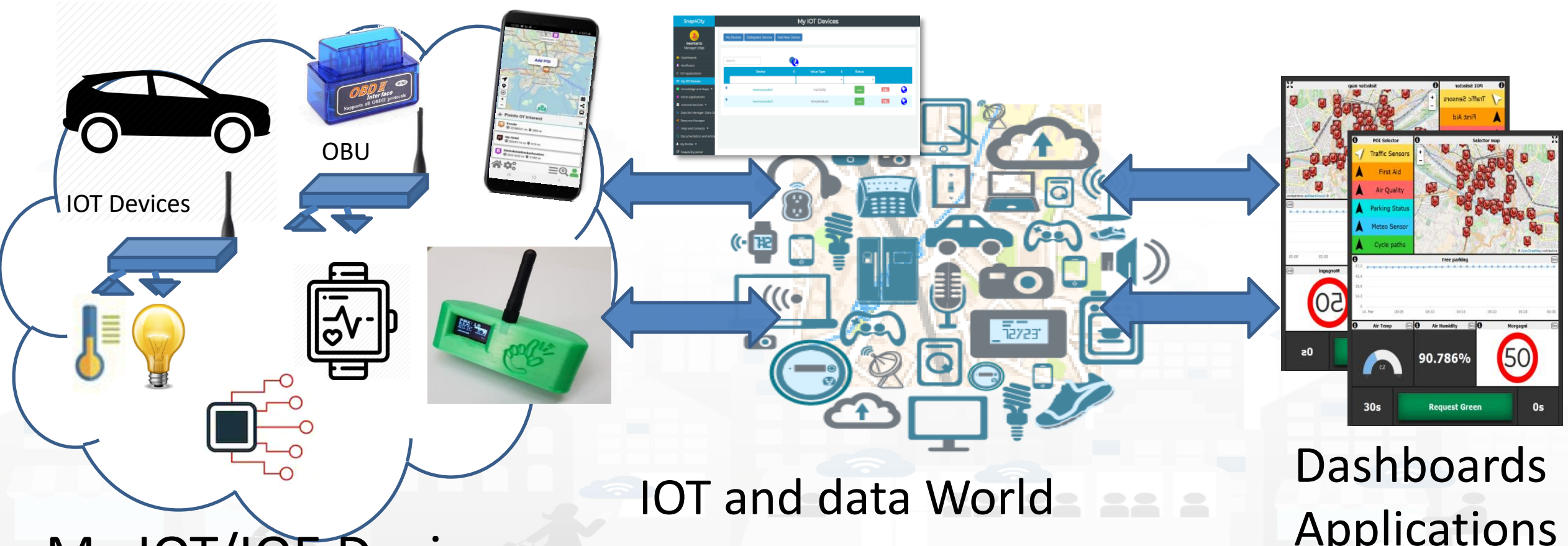
Towards any IOT Device and/or Dashboard

Dashboards also provide rendering for sensor values



To Start we are going to use Direct Dashboards

Dashboards accessing data available on Platform, including your own data coming from Mobile App, already registered!!!



My IOT/IOE Devices

IOT and data World

Dashboards Applications

IOT Architecture

IOT Device

IOT Device

IOT Device

IOT Device

FI-WARE IOT Orion Broker

AMQP

COAP

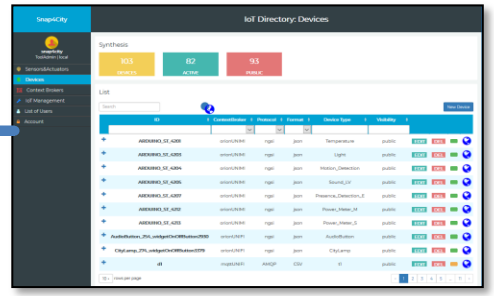
sigfox

THE THINGS NETWORK TheThingsNetwork

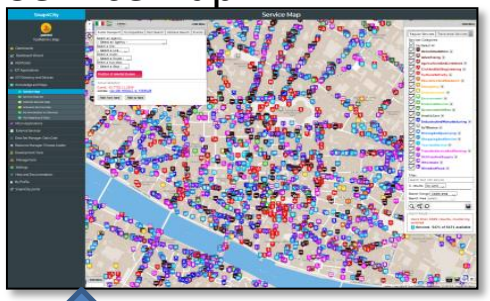
One M2M

.....

IOT Directory



ServiceMap



Registering
Discovery

Browsing
Discovering

Data Shadow,
Elastic Search

Knowledge Base,
Km4City

Advanced Smart City API

Snap4City MicroServices Node-RED

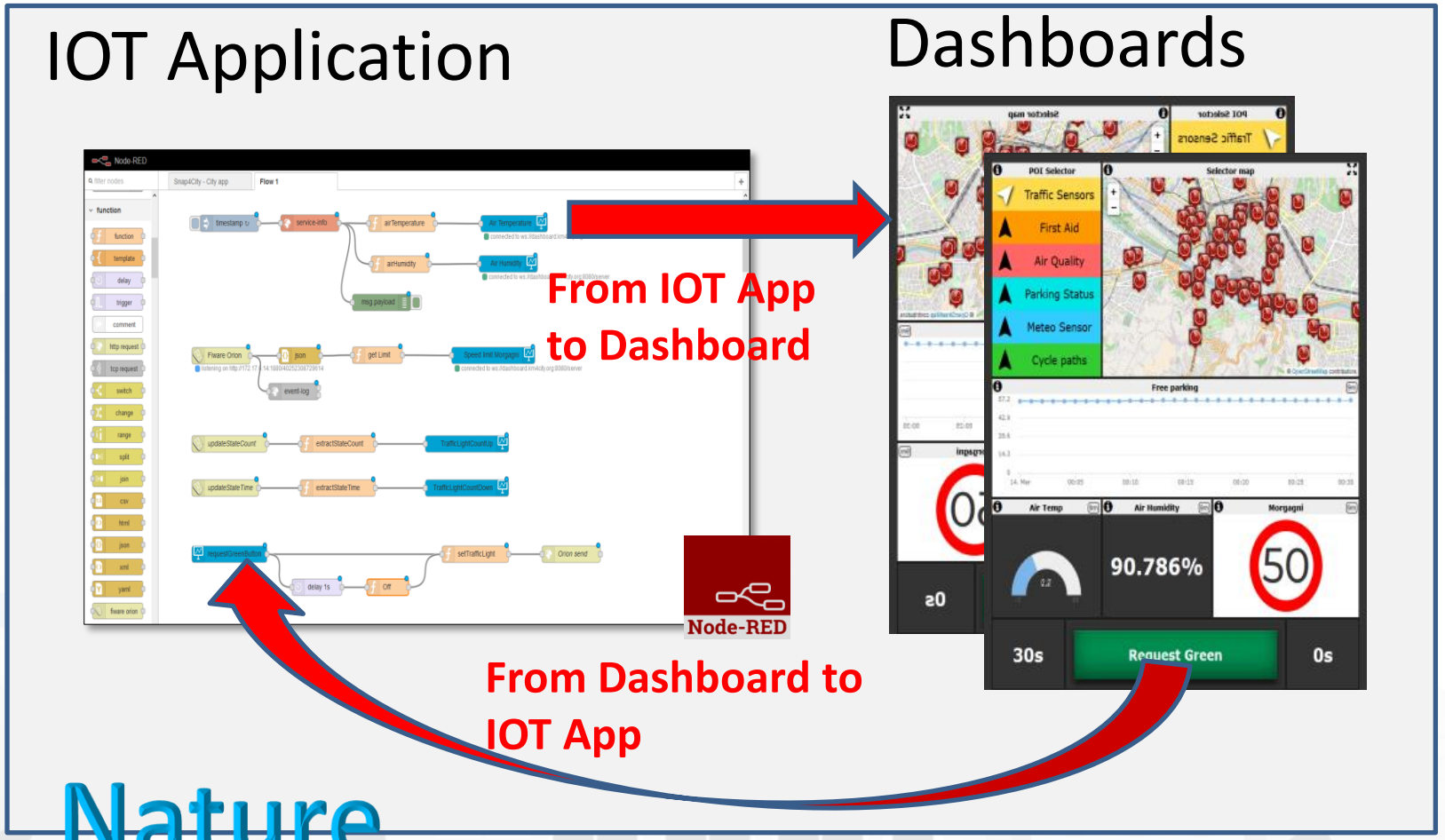
Elastic Management of IOT Applications

Dashboard

HLT: Sensors-Actuators

High Level Types

- **Complex Event**
- **Dashboard-IOT App**
- **External Service**
- **Heatmap**
- **KPI (Key Performance Indicator)**
- **MicroApplication**
- My Personal Data
- MyKPI
- MyPOI
- **POI (Point of Interest)**
- **Sensor**
- **Sensor Actuator**
- **Special Widget**
- Wfs (GIS)



UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

SNAP4CITY

IOT/IOE on the field

On Cloud

(1) Registration

(0) Sensors & Actuators

Raspberry pi

Sensors/ Actuators

IOT Directory

(2) Discovery

Sensors/ Actuators

Sensors/ Actuators

Internet

-- PC: Win, Linux

Sensors/ Actuators

IOT Edge
With IOT App distributed

(1) Registration

Sensors/ Actuators

IOT Button

IOT Brokers

Mobiles

Sensors/Actuators

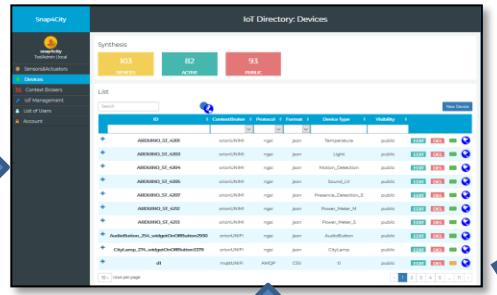
IOE Devices

IOT Network Manager vs Final User

Network of IOT Brokers

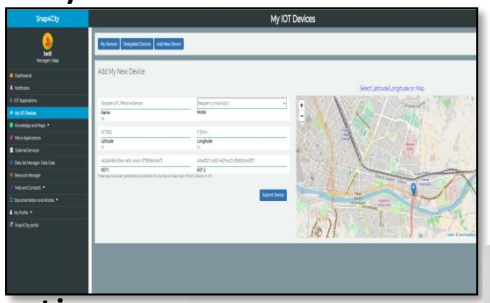
IOT Broker

IOT Directory



IOT Network Manager

My IOT Device



Register

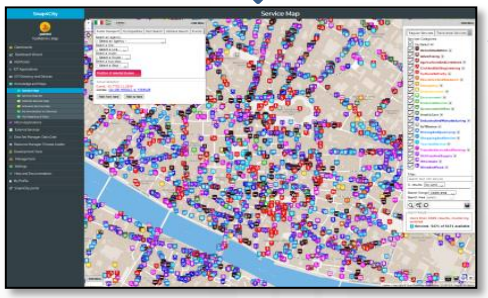
Registering

Discovering

Knowledge Base, Km4City

Knowledge and Storage Data from the Field and City

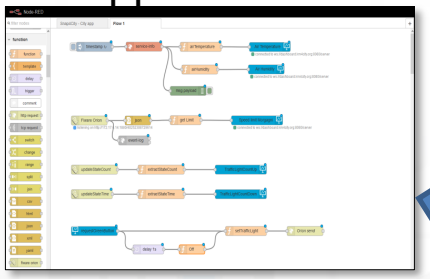
Browsing



ServiceMap Knowledge Base

Discovering

IOT Application



Final user Manager

Dashboard Wizard

Main Features of the IOT Directory

- **Registers IOT Brokers**
  - Different kind of Brokers, different kinds of authentications and protocols
  - Registered IOT Orion Brokers can be queried for collecting their managed devices, so that those IOT Devices are registered
- **Registers IOT Devices**: singularly or at groups (in Bulk)
  - Registration can be custom or based on IOT Device Model
  - IOT Edge are registered as special IOT Devices
  - Registered IOT Devices are saved into local Data base and Knowledge Base
- **Provides support for security aspects**:
  - Generation of Certificates, Keys, etc.
  - Collection of keys when IOT devices are on some IOT Gateway or Second Level IOT Broker.
- **Manages Ownership and Delegation** for
  - IOT brokers, IOT devices, IOT Device Values

IOT Directory Features vs Users Roles

Entities	what	By using	Manager	AreaManager	ToolAdmin/RootAdmin
IOT Sensor/Actuator	Browse, use	Several Tools	X	X	X
	Delegate	IOT Directory	X	X	X
	Discovery	KB, API, MicroServices	X	X	X
IOT Devices	Browse, use	Several Tools	X	X	X
	Add/change/Delete	IOT Directory, API, ..	X	X	X
	Add in Bulk	IOT Directory, API, ..			X
	Delegate	IOT Directory	X	X	X
	Discovery	KB, API, MicroServices (MS)	X	X	X
IOT Device Model	use	IOT Directory	X	X	X
	create	IOT Directory		X	X
IOT Broker	Browse, use	IOT Directory	use	Browse, use	X
	Add/change/Delete	IOT Directory			X
	Delegate	IOT Directory			X
	Periodic Update	IOT Directory			X

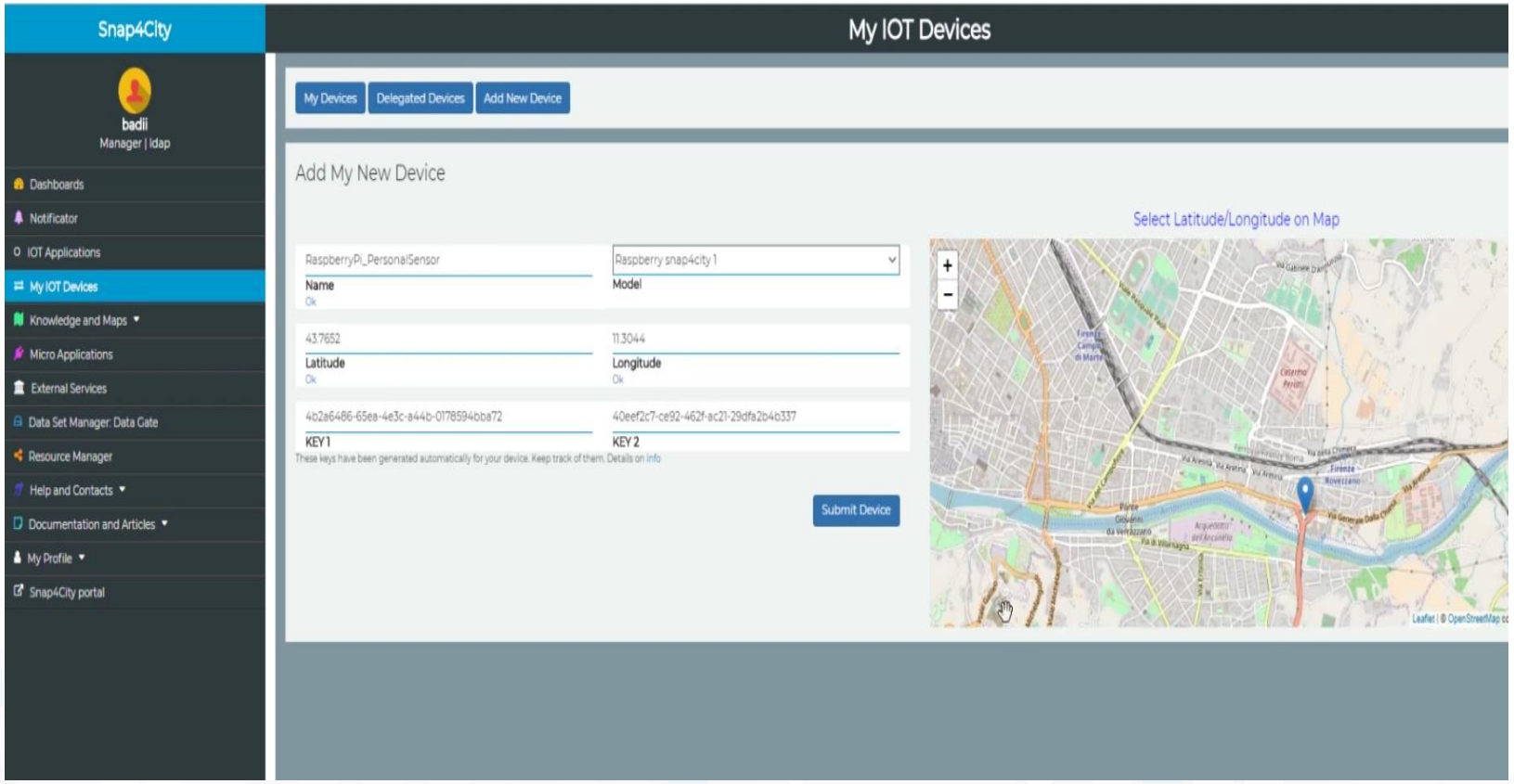
Add IOT/IOE Devices

Just Buy an IOT Device and register: SigFOX, MQTT, FiWare, …

- Attach them by
  - Models
- A range of protocols, formats, approaches

Create your own devices:

- Arduino,
- Raspberry,
- Android,
- LoraWAN + Arduino,
- etc.

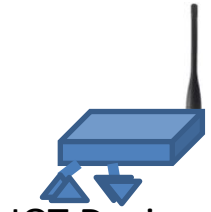


Secure Communication: HTTPS, TLS (K1, K2), Certificates

In which case you are?

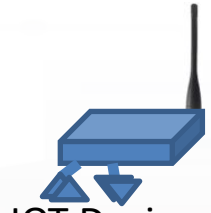
https://www.snap4city.org/drupal/node/474

IOT Broker — SNAP4CITY — Case B2



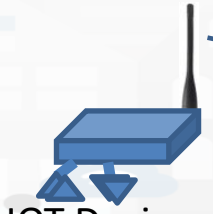
IOT Broker → SNAP4CITY — Case B1

i) Registered IOT Broker on Snap4City



a) Registered IOT Device on Broker

IOT Broker — SNAP4CITY — Case A1.2

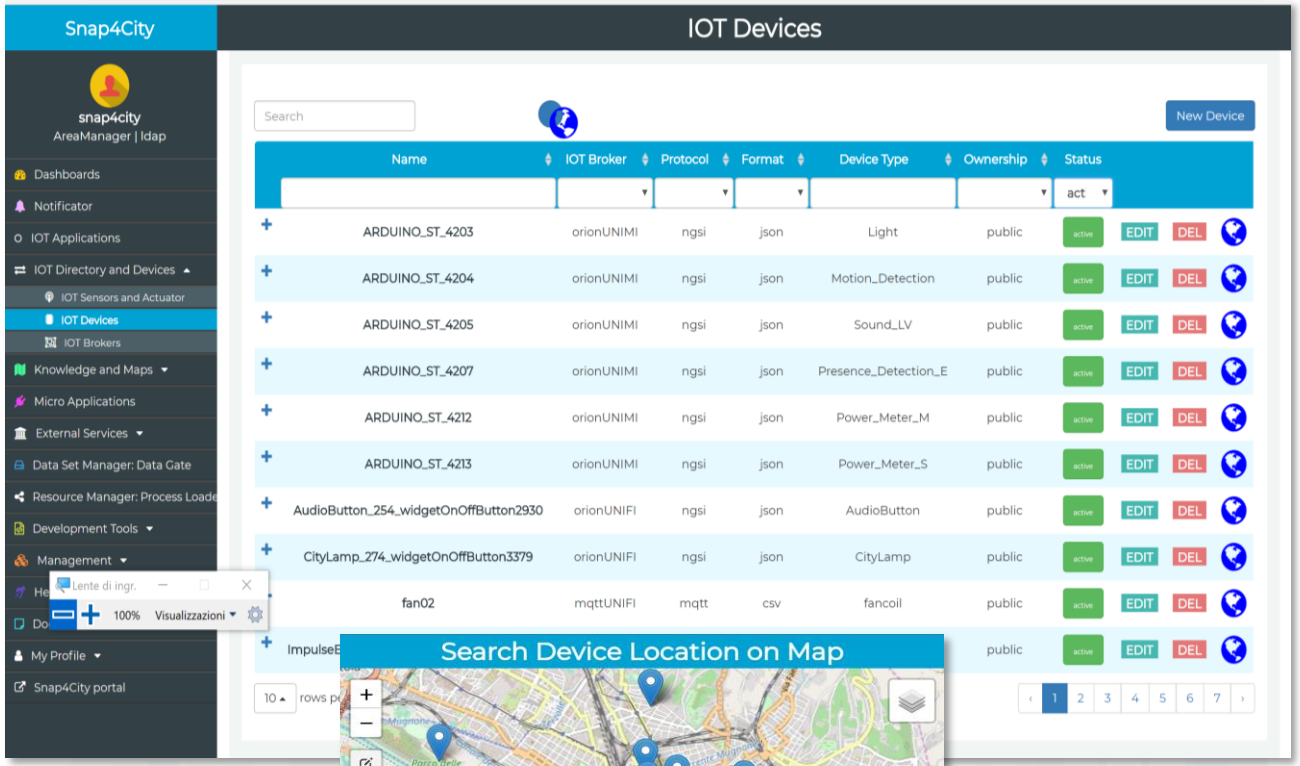


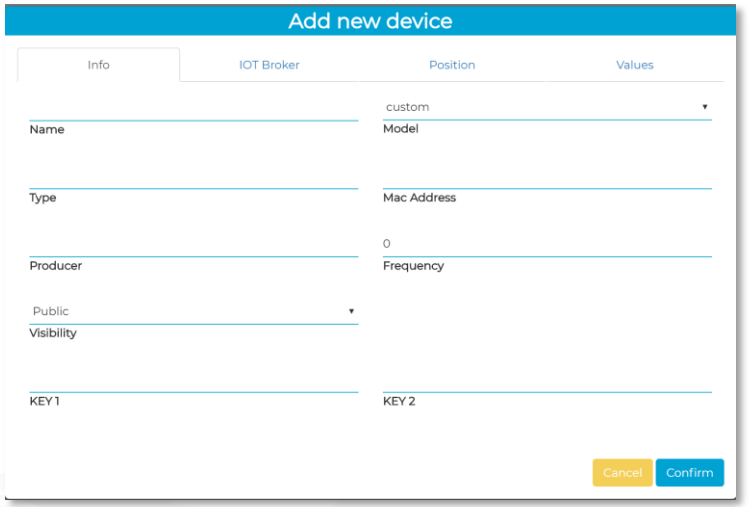
a) Registered IOT Device on Broker

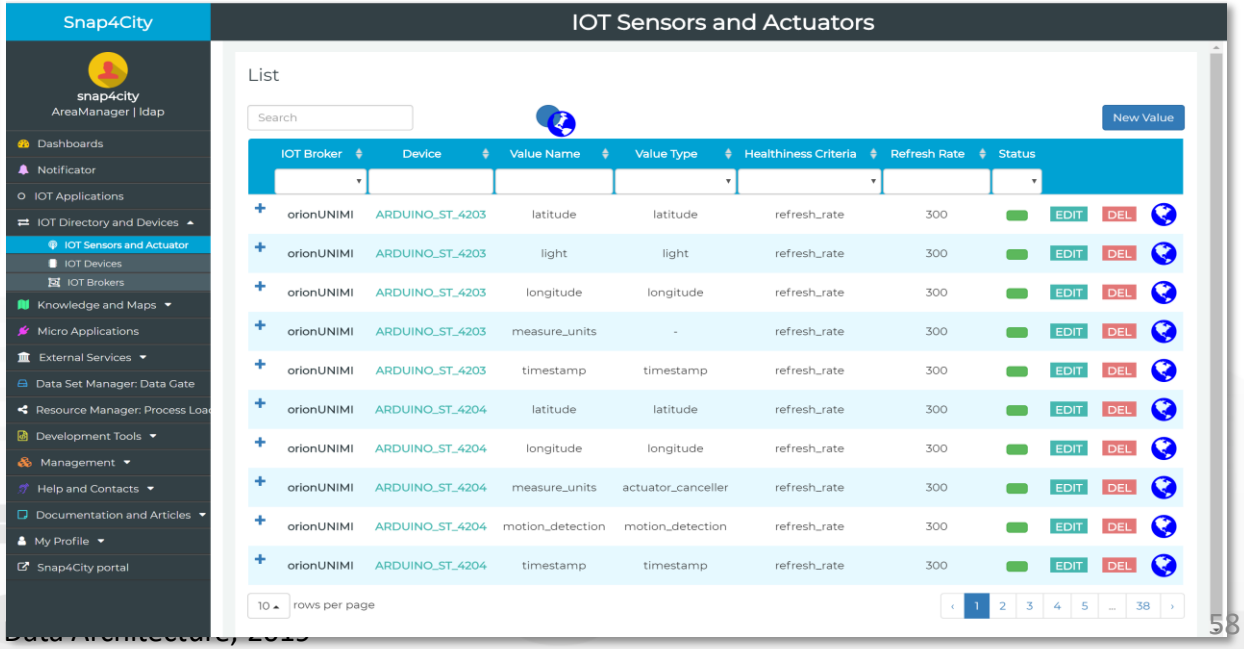
IOT Broker → SNAP4CITY — Case A2

i) Registered IOT Broker on Snap
ii) Registered IOT Device on Snap

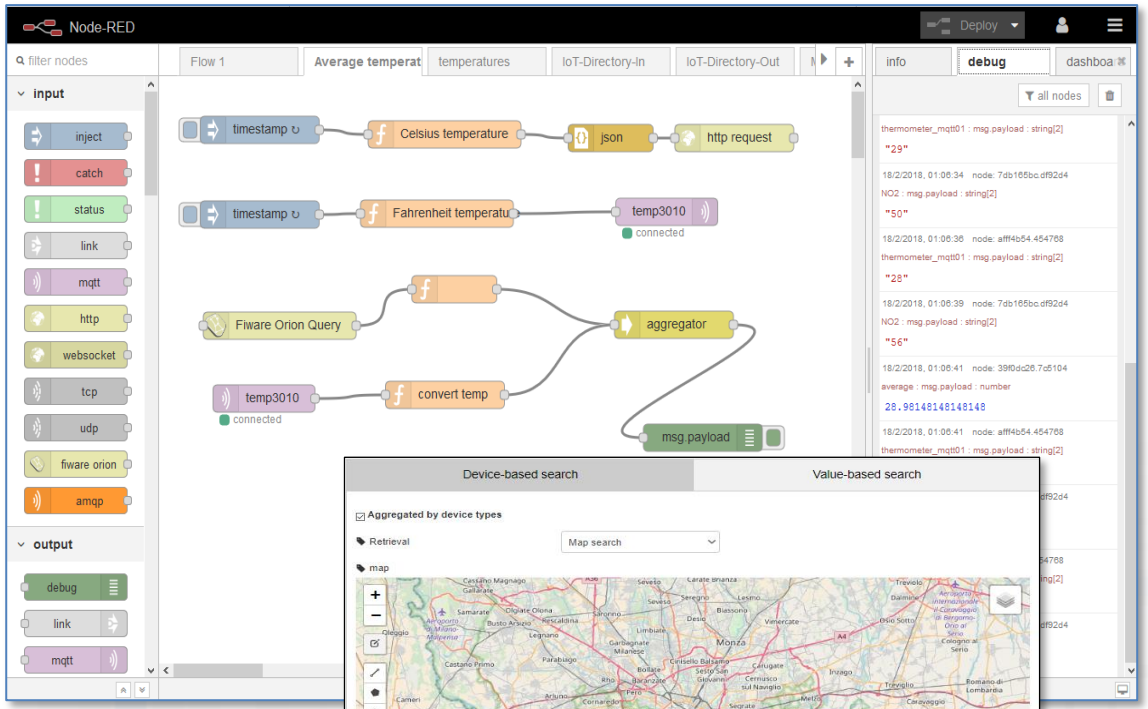
IOT Directory

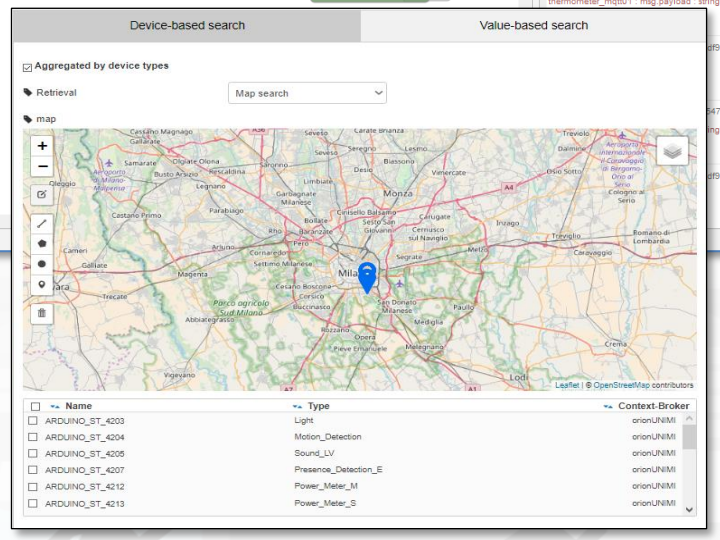


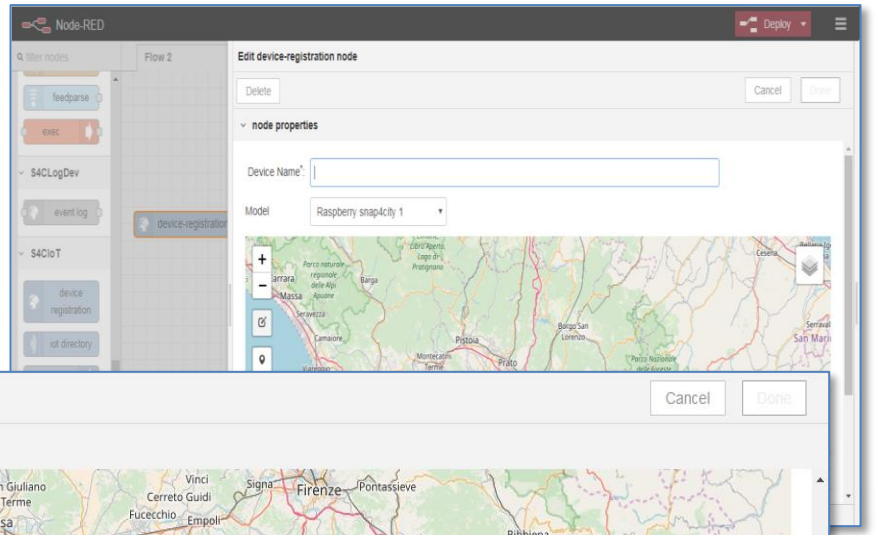


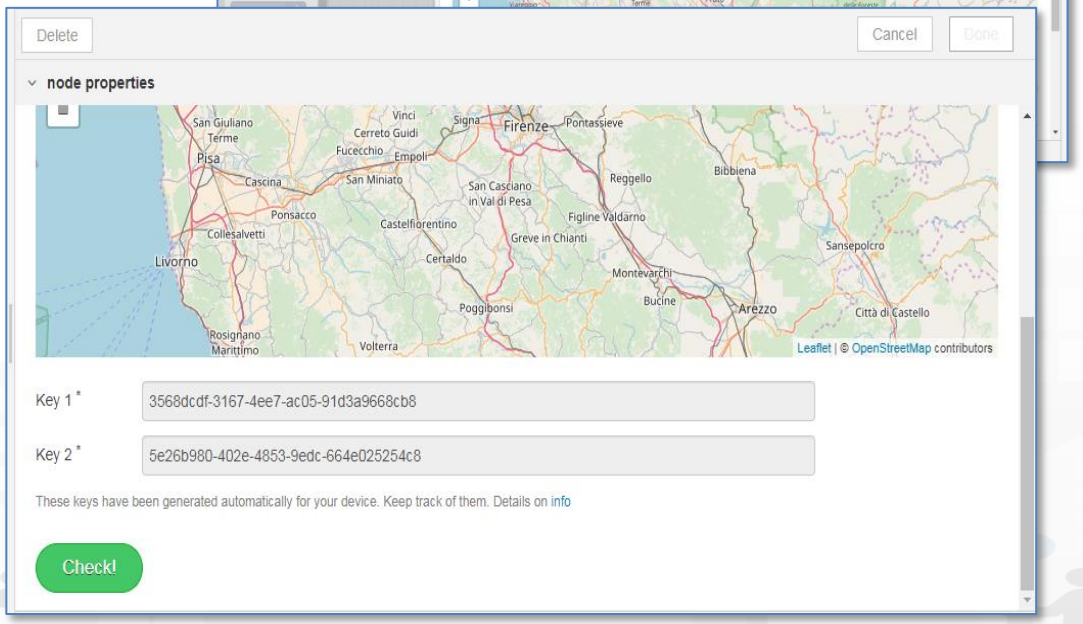


IOT Discovery on IOT Application Development









Exercitations

- Create a flow and app that:
  - when you press a button on the screen
  - provides you the arrival time of your preferred bus at your preferred busstop
- Create a flow and app that
  - When you press a button on the screen
  - provides you the list of the final destinations of the bus lines that pass from the bus stop:
    - 1) near to you at that moment or
    - 2) one that you chose.
    - 3) Or a fixed one
- Create a flow and app that
  - When you press a button on the screen
  - provides you the list of the final possible POI that you can reach
    - 1) at a reasonable walking distance of 500 meters
    - 2) using the bus lines that pass from the bus stop, and that can allow you to reach the places within 20 minutes max
- Create a flow and app that:
  - Keep you informed any way, every 3 minutes
  - Providing you the next time of arrival of your preferred bus at your preferred busstop
    - presenting information on mobile screen
    - sending information via telegram
- B

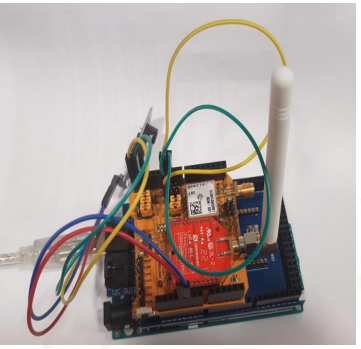
Proprietary IOT Devices as well as Open Hardware / Open Software

IOT Devices

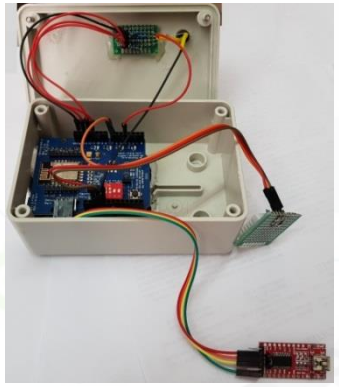
Sensors/
Actuators

IOT Edge Devices

LoraWAN +
Arduino +
I2C, NGSI



Arduino,
Wi-Fi, NGSI

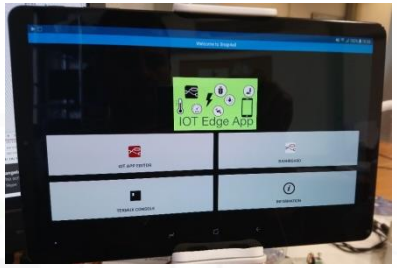


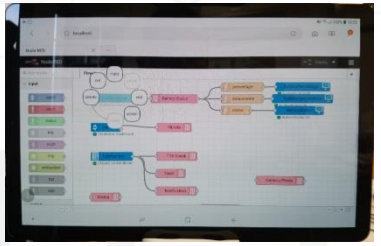
Snap4All
IOT Button
ESP, NGSI,
Wi-FI, BT

Snap4All PAX
Counter
LoraWAN
WIFI, NGSI,
GPS

IOT Edge
NodeRED:
Raspberry Pi,
NGSI, WiFi,
RJ45,..

IOT Edge
NodeRED:
Android, LINUX,
Windows, …

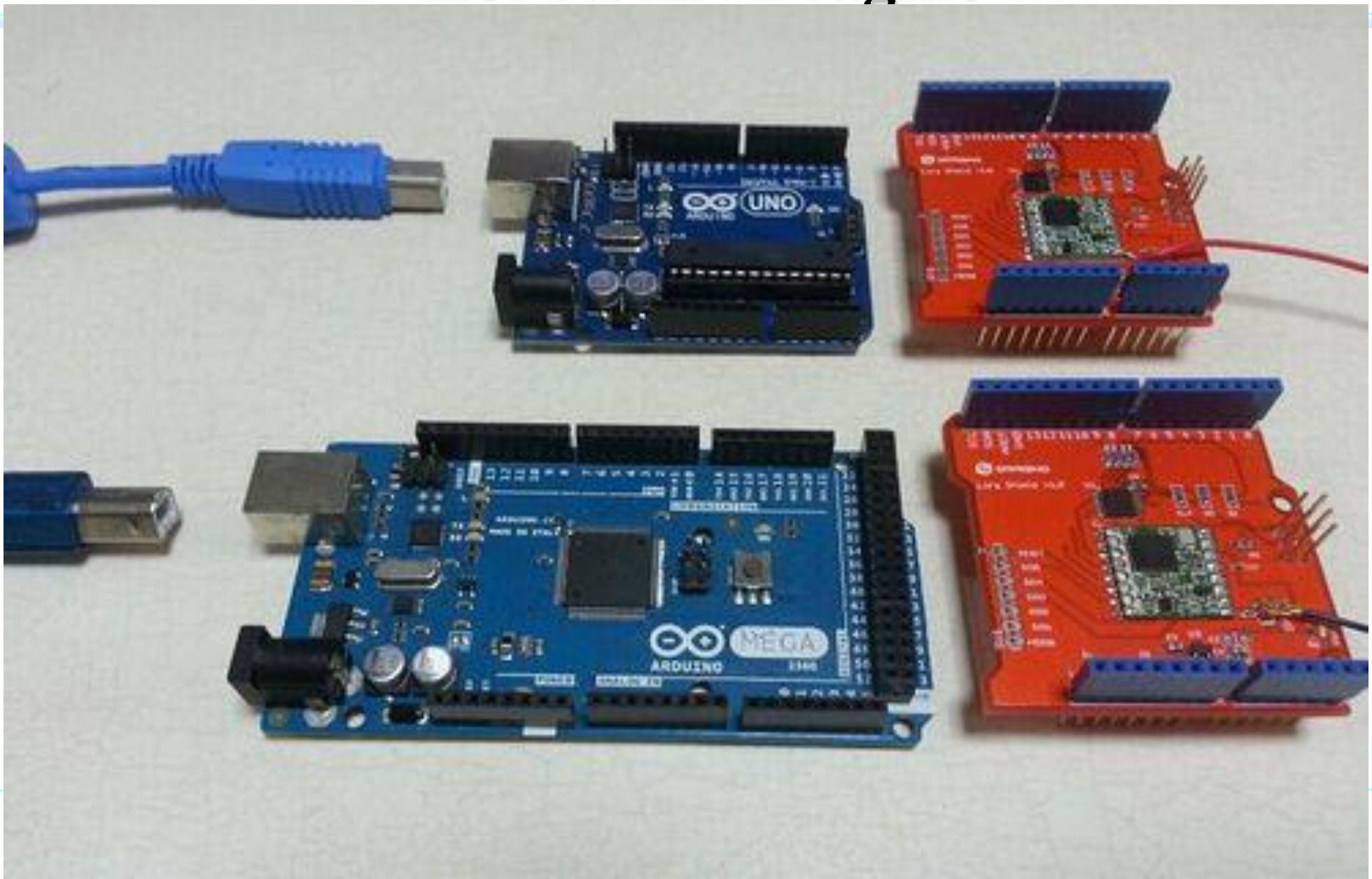




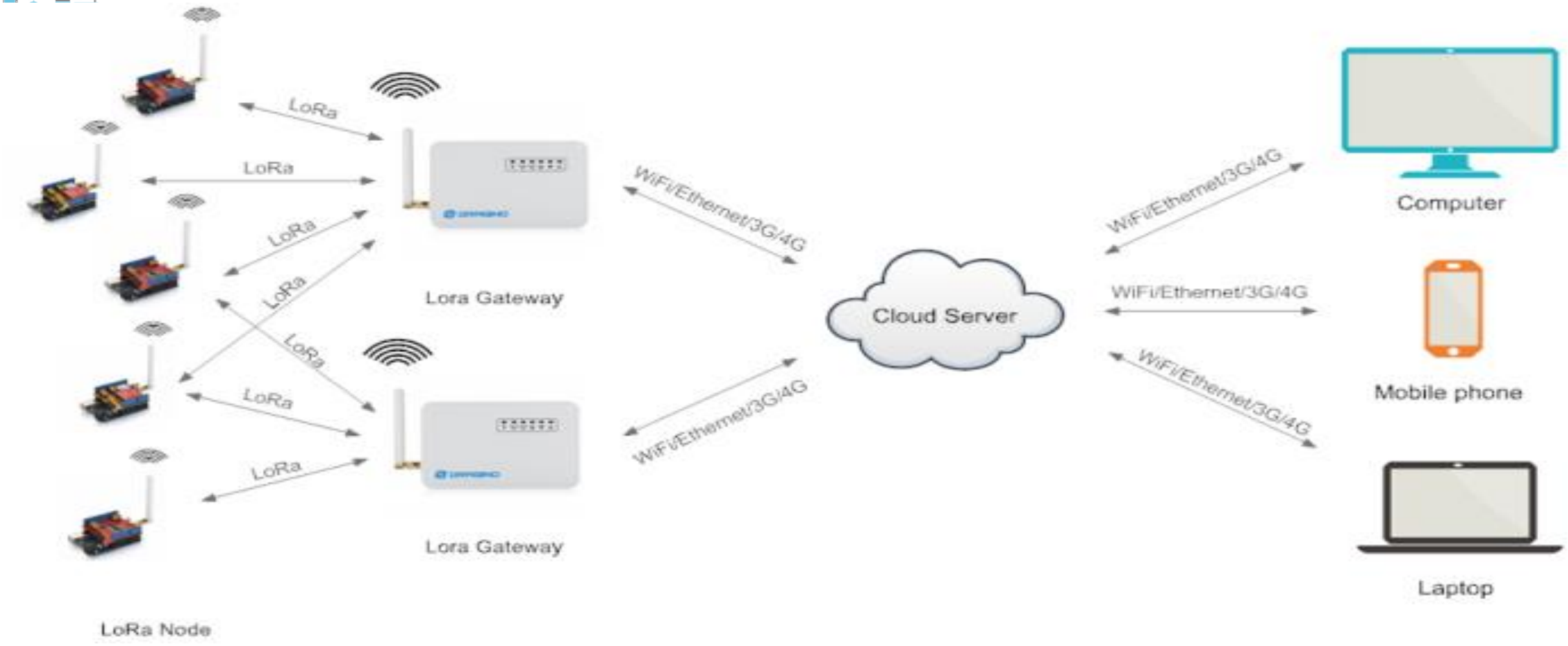
LoraWan
Gateway:
IOT Edge, NGSI,
WIFI, RJ45, GPS

Any Sensor / Actuator
Open to other protocols

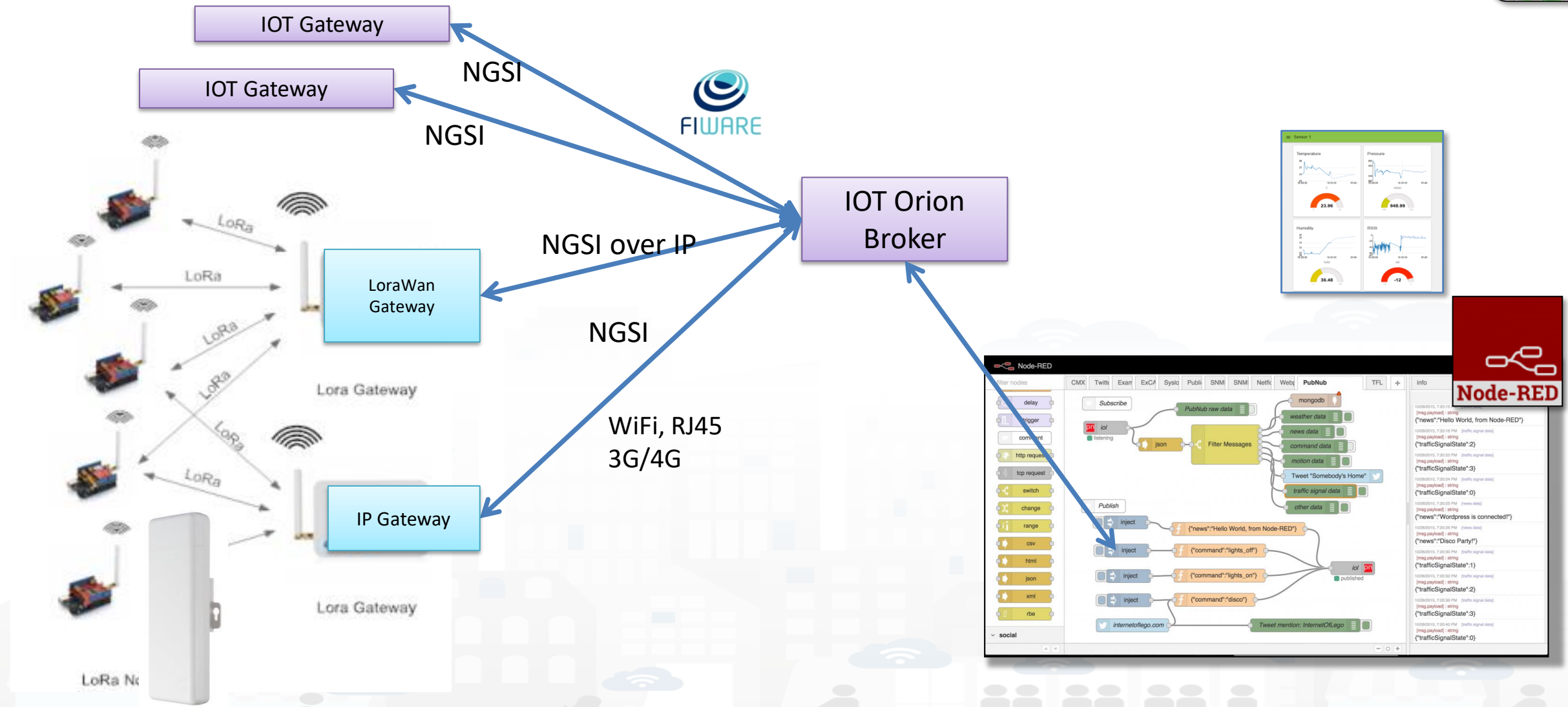
LoraWAN Dragino



LoraWAN Dragino (Arduino)

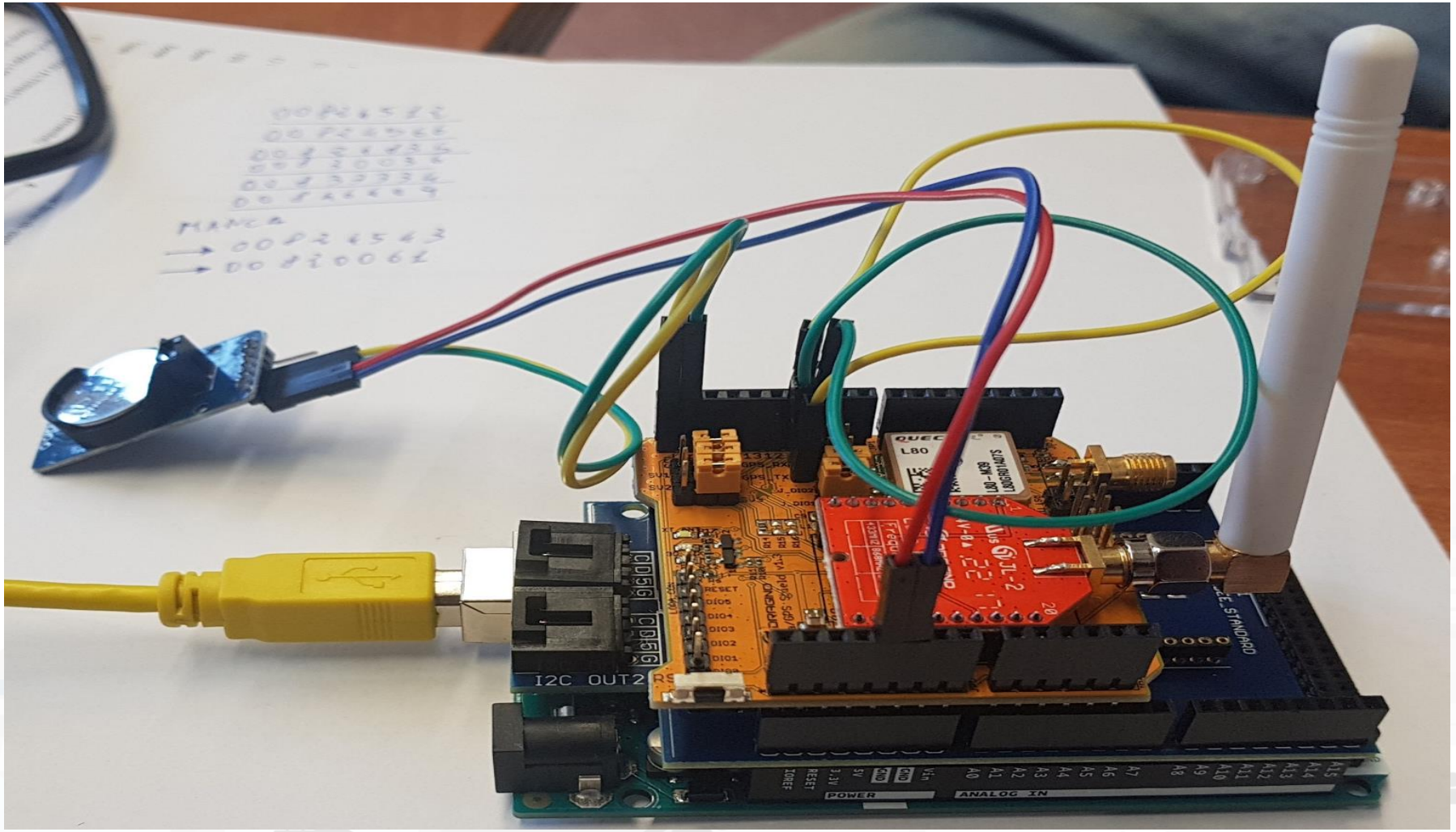


IOT Management



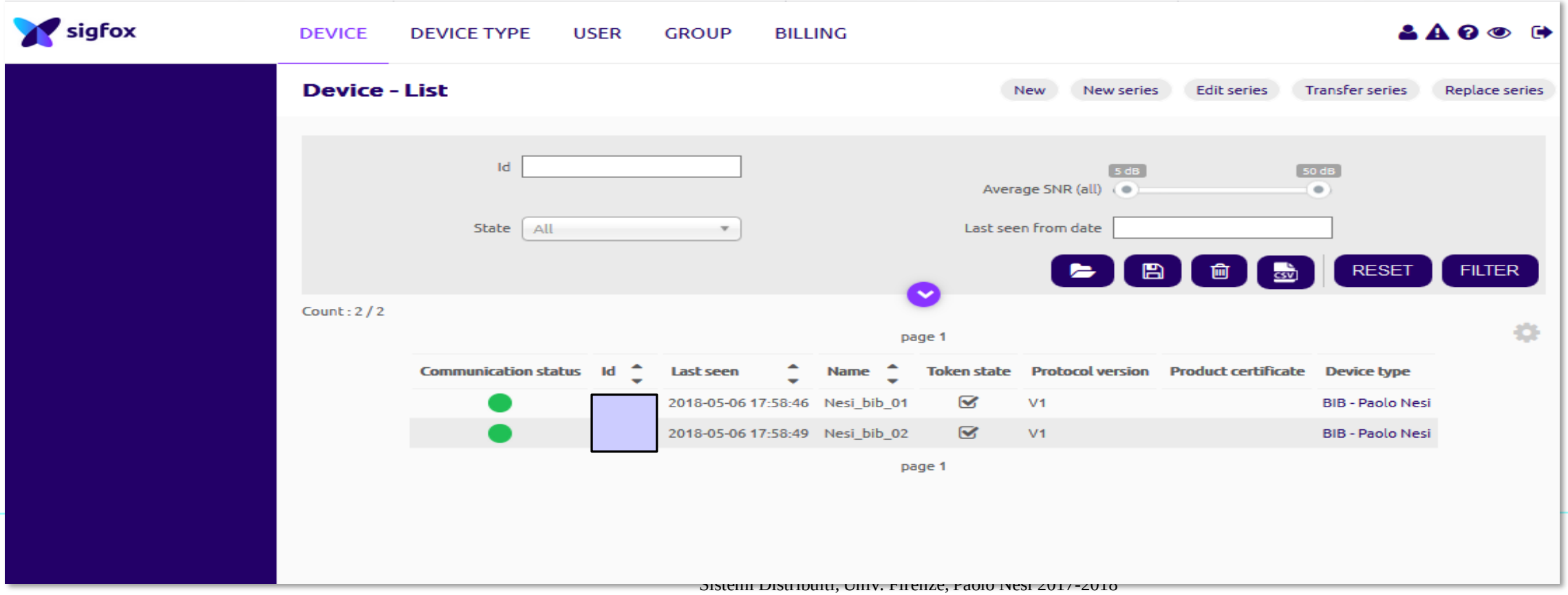
Dragino……

Piattaforma di sviluppo per LoraWan



SigFOX Server Side

- Proprietary Protocol
- Final users, consumers may buy SigFox devices and subscribe to network to register their devices
- Limited number of msg per day, per year

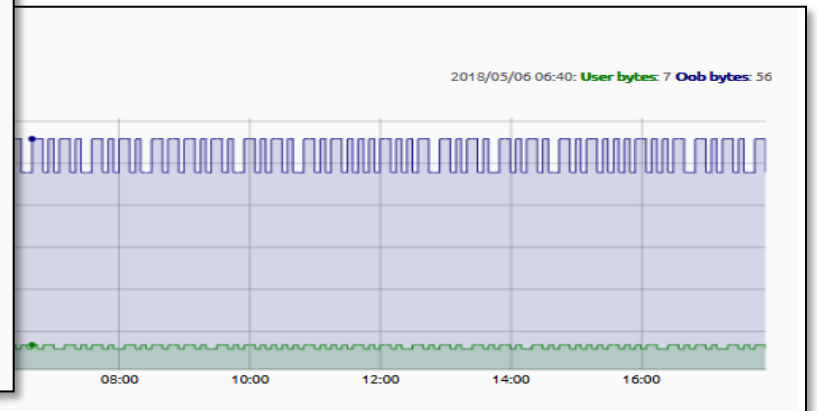


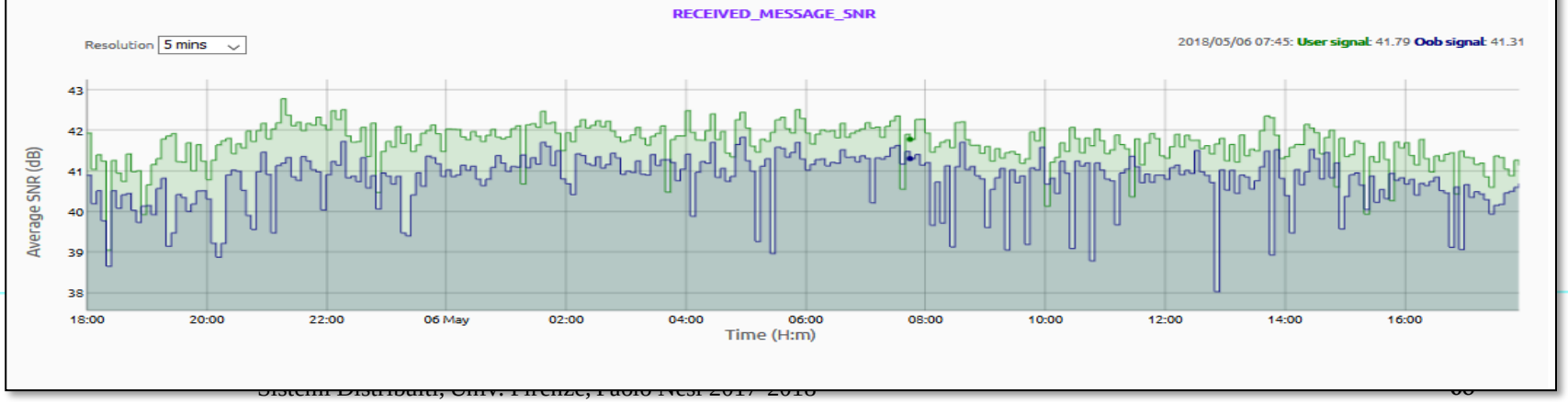
SigFOX

page 1

Frame reception time

Time	Delay (s)	Header	Data / Decoding	Location	Base station reception attributes: Base station	RSSI (dBm)	SNR (dB)	Freq (MHz)	Frames	Callbacks
2018-05-06 18:03:27	< 1	0000 ack required	24		28A8	-122.00	29.40	868.1491	3/3	
					2896	-136.00	15.60	868.1420	3/3	
					25F2	-119.00	32.03	868.1373	3/3	
2018-05-06 18:03:25	< 1	0010	09dd0b4f0b040103 Temp: 26.0 °C VDD idle: 3.037 V VDD tx: 2.895 V RSSI: -97.0		25F2	-120.00	31.57	868.1187	1/3	
					28A8	-122.00	29.05	868.1185	1/3	
					2627	-141.00	10.48	868.1173	1/3	
2018-05-06 18:02:51	< 1	0000 ack required	24		28A8	-122.00	29.39	868.1357	3/3	
					2896	-136.00	14.81	868.1347	3/3	
					2884	-134.00	17.36	868.1229	3/3	
2018-05-06 18:02:23	< 1	0010	09d30b4a0b0e0102 Temp: 27.0 °C VDD idle: 3.027 V VDD tx: 2.890 V RSSI: -98.0		23DB	-110.00	41.00	868.1449	1/3	
					2896	-137.00	14.40	868.1442	1/3	
					2889	-137.00	13.67	868.1447	1/3	
2018-05-06 18:01:48	< 1	0000 ack required	24		23DB	-109.00	41.66	868.1553	1/3	
					2889	-136.00	15.06	868.1550	3/3	
					28C8	-139.00	11.81	868.1546	1/3	





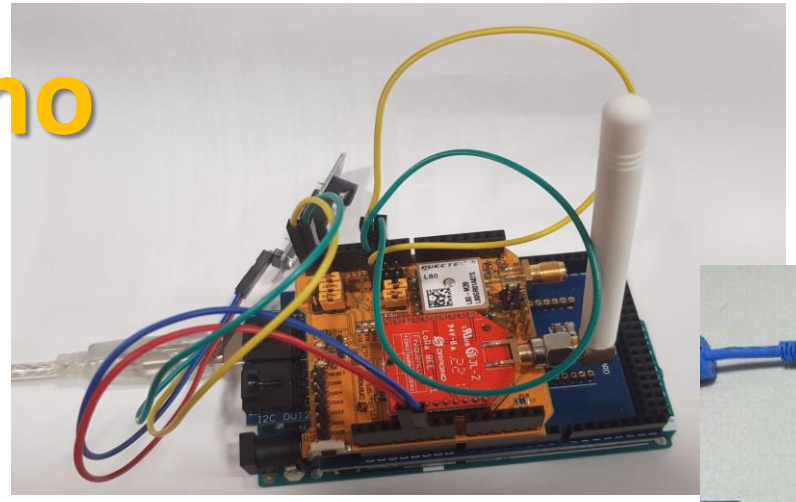
SigFOX piattaforma di sviluppo

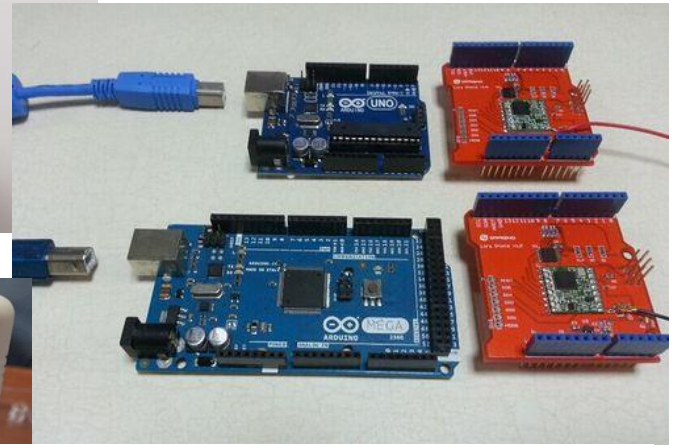
IOT Dev Management: activities

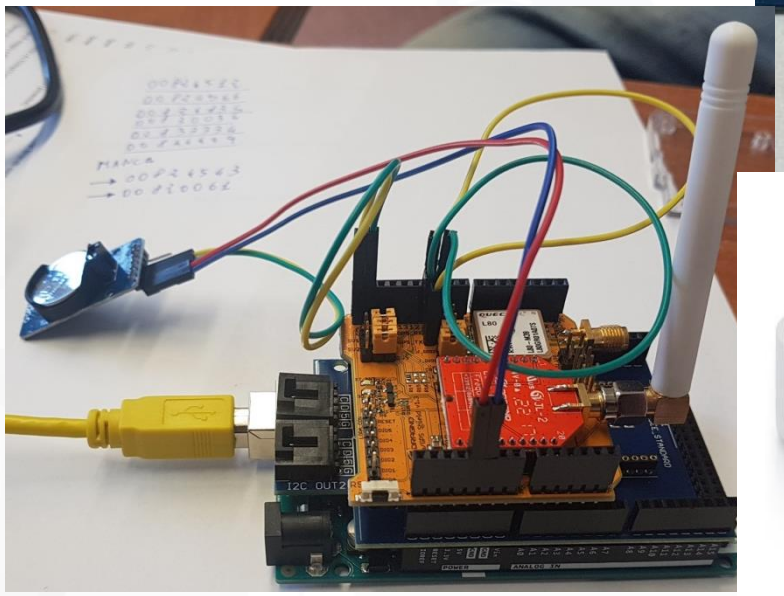
- **IOT Devices can be open or proprietary**
- **IOT Devices**: a large range of protocols, formats and kind
  - IOT Devices (single or in bulk) are **registered** on IOT Directory and thus according to Knowledge base are registered to be used in IOT Applications, Dashboards, etc. with Shadow values, etc.
  - IOT Models are saved on IOT Directory for shortening the registration process
  - IOT Device healthiness is monitored automatically
- **IOT Devices can be public or private**
  - **Full support of Proprietary protocols and devices**
  - **Providing Open Hardware and Open Software** IOT Devices/IOT Edge: NGSI fully secure
- **IOT Edge** are devices with some computing capability, realized by using: Raspberry, Android, Linux, Windows, etc.
  - **Release as**: OS images on SD, APK for Android, Virtual Machine, Docker Container, etc.
- IOT Devices are connected via **Secure Encrypted Mutual Authenticated** channel of communication

Lora IOT Device, Arduino

- Arduino Uno, Mega
- LoraWan Connection
- Any sensor, + I2C
- Fully Customizable
- Open Source
- NGSI or any other protocols
- Gateway: Dragino



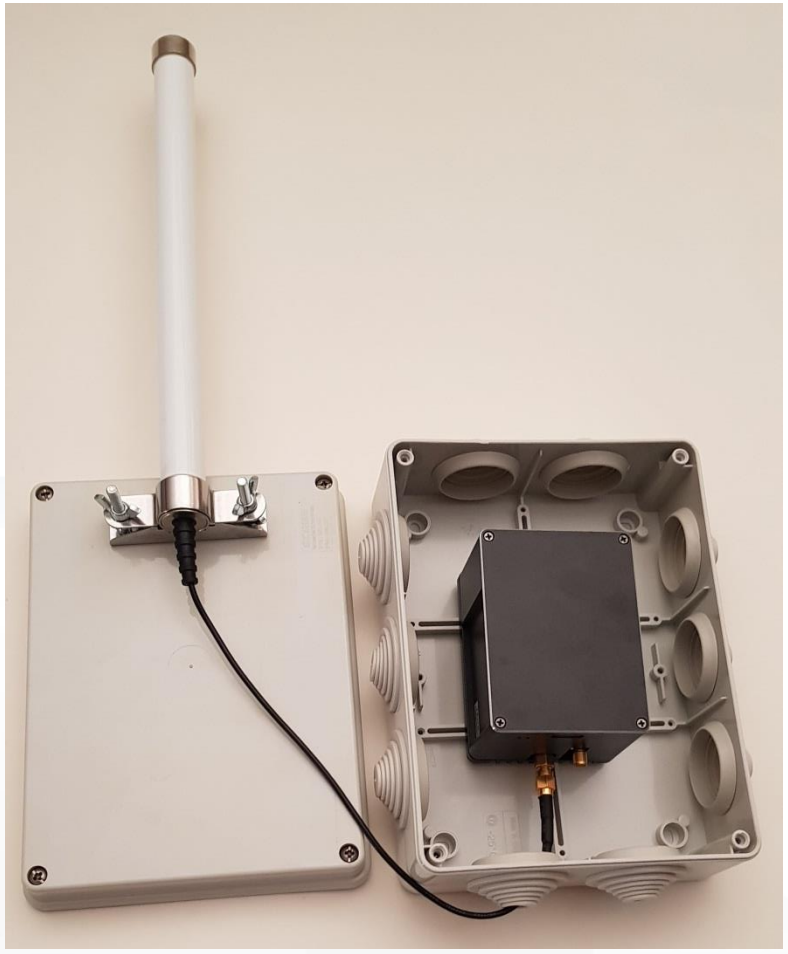




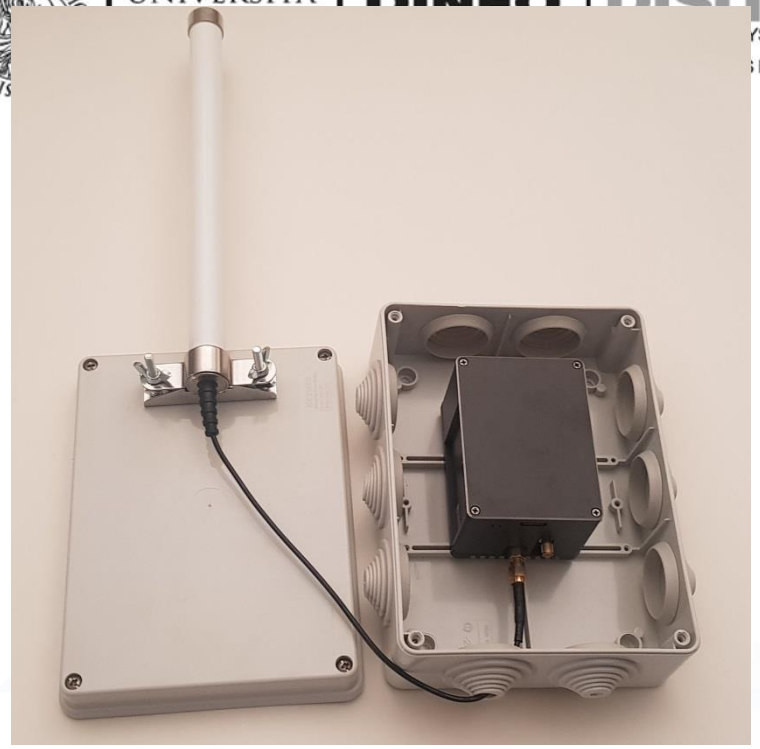
https://www.snap4city.org/drupal/node/216

LoraWan Gateway out of the Box

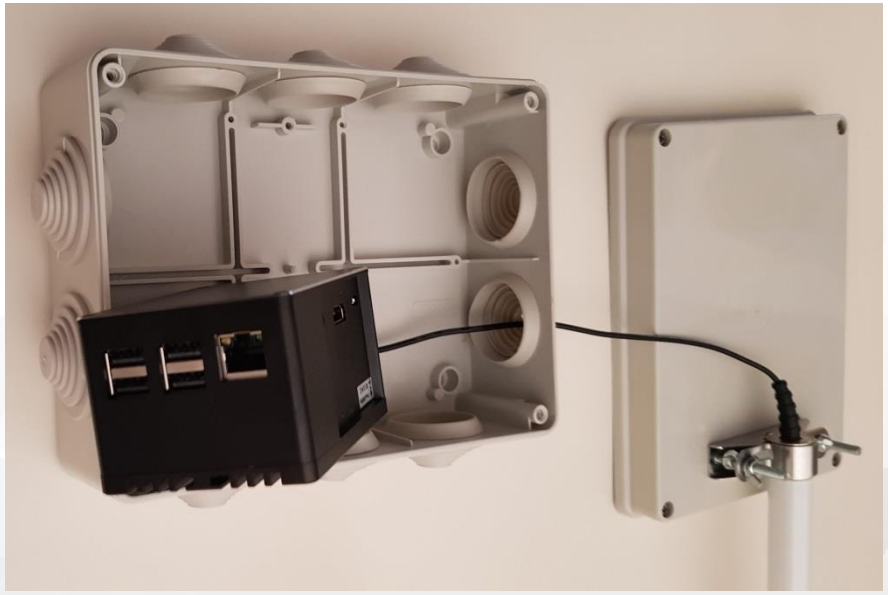
- Raspberry Pi Based LoraWan Gateway
- Physical UpLink as: Wi-Fi, RJ45
- Logical UpLink: LoraWAN TheThingsNetwork, NGSI V2 (mutual authenticated Snap4City)
- Powered 5V
- GeoLocated GPS Antenna
- IOT Edge Snap4City Included if needed



FIWARE LoRa Wi Fi

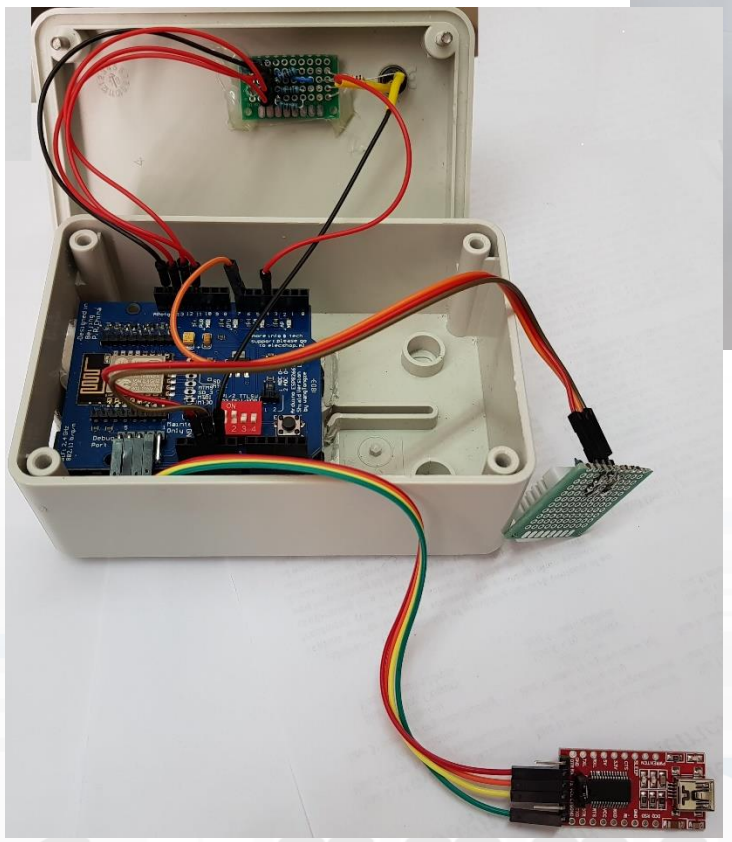


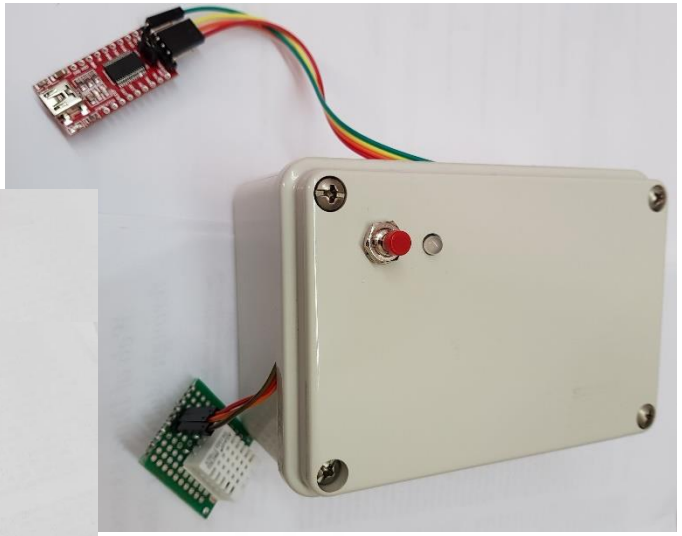
SigFOX
Any and
Arduino



IOT Device with Arduino

- Arduino Uno
- Wi-Fi shield, standard
- Mutual Authentication with certificates, or K1,K2,sha
- Secure encrypted connection, NGSI
- Open Source
- Fully Customizable
  - Any sensor
  - NGSI or any other protocol

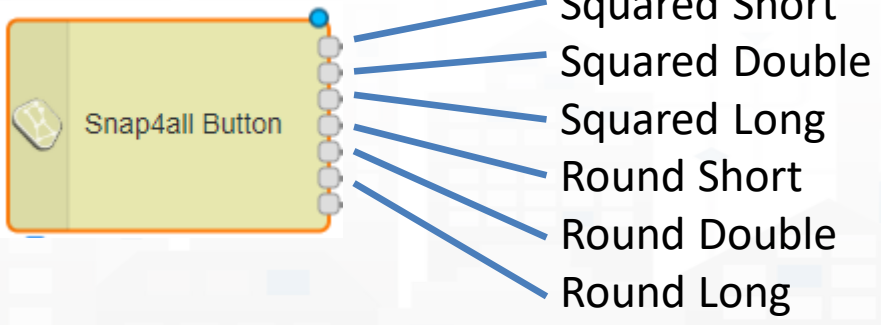




Snap4All IOT Button

- Multi Wi-Fi
- Ready to use BLE
- ESP based, cheap & easy
  - low/no energy consumption/ standby
- Mutual Authentication with certificates, or K1,K2,sha
- secure encrypted connection, NGSI
- Open Source, Fully Customizable
- HW extensible to sensors

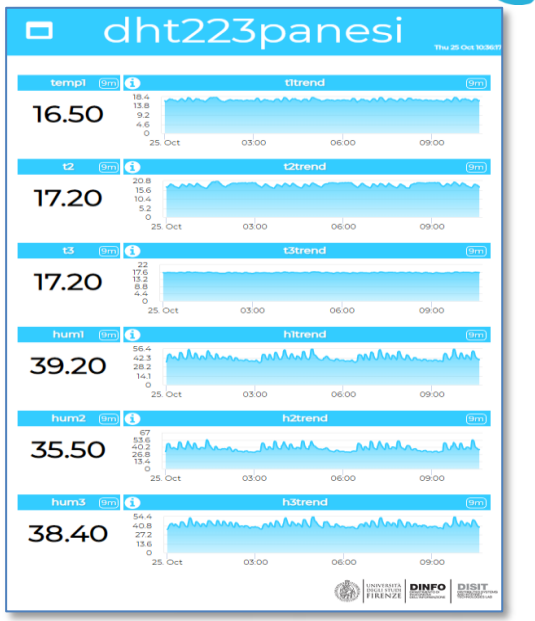
version: 3

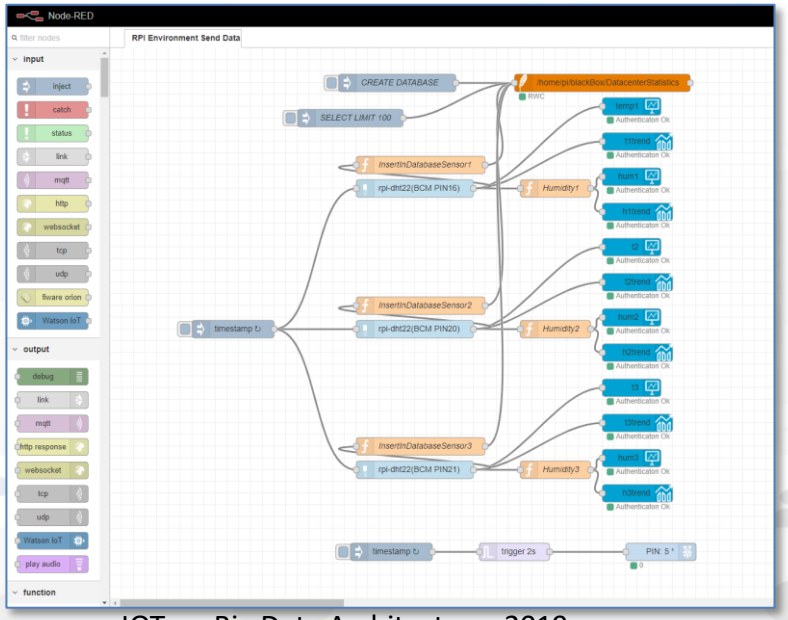


https://www.snap4city.org/drupal/node/276
https://www.snap4city.org/drupal/node/297 help config

IOT Edge on Raspberry Pi

- Raspberry Pi
- Mutual Authentication with certificates
- Secure encrypted connection
- IOT Application inside
- Any sensor
- Any protocol from IOT devices
- NGSI or any other protocol
- Fully Customizable
- Local and Cloud Dashboard
- **Special MicroServices**

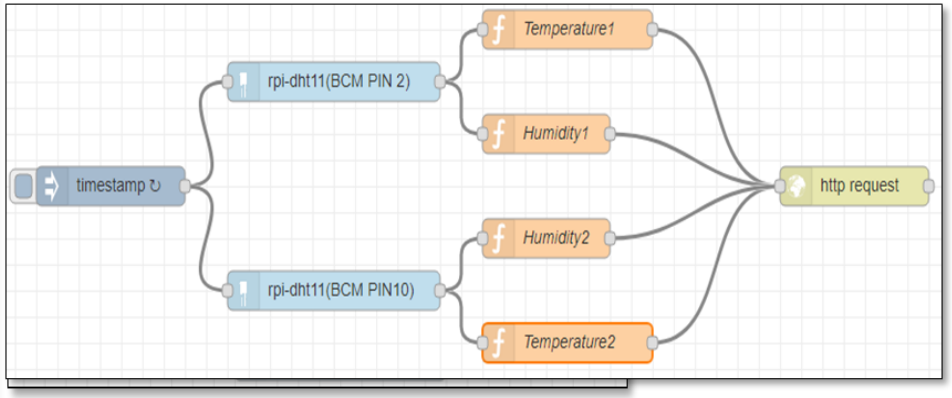


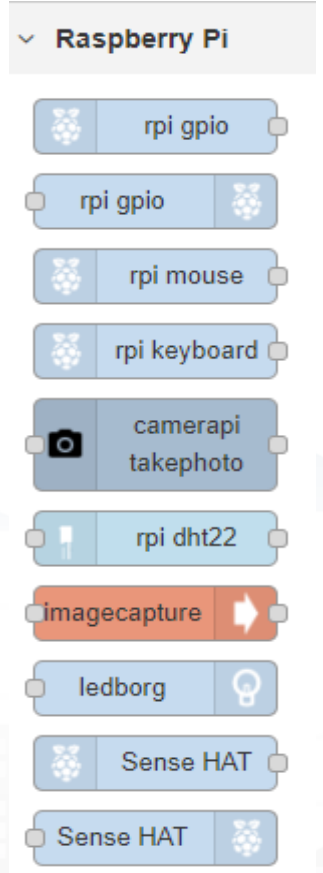


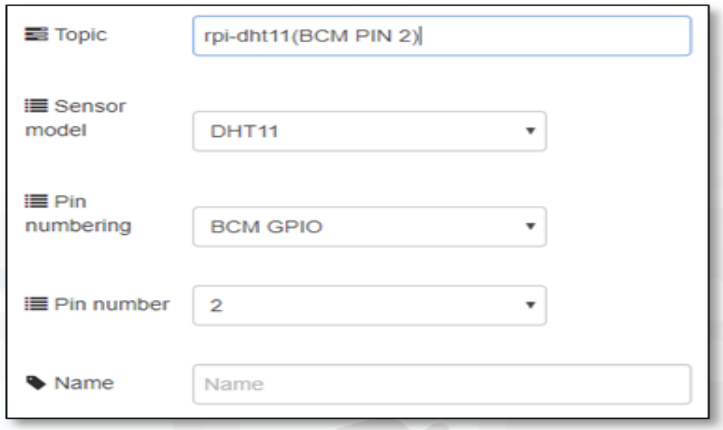
MicroServices:
- DHT
- ModBus
- any shield
- etc....

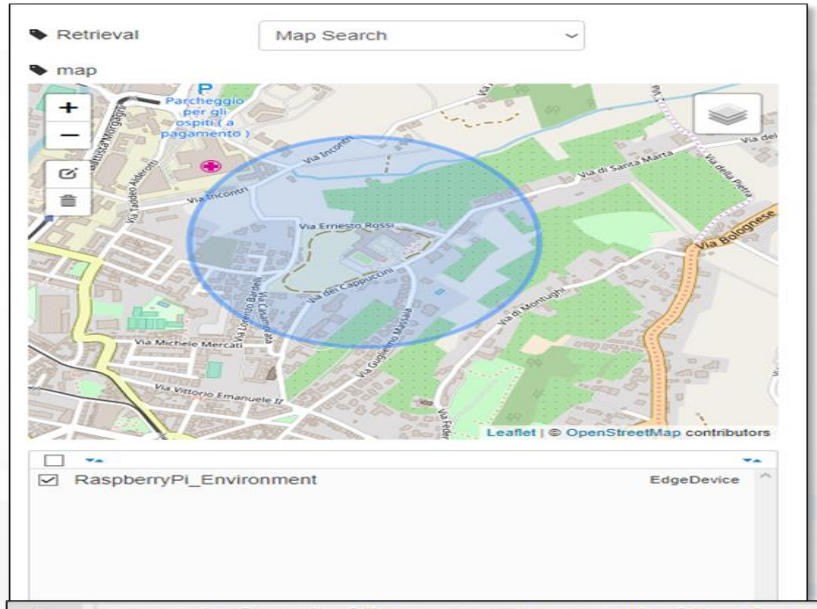
Raspberry for Edge

3.3V Power - 1	2 - 5V Power
SDA1 - GPIO02 - 3	4 - 5V Power
SCL1 - GPIO03 - 5	6 - Ground
GPIO04 - 7	8 - GPIO14 - TxD
Ground - 9	10 - GPIO15 - RxD
GPIO17 - 11	12 - GPIO18
GPIO27 - 13	14 - Ground
GPIO22 - 15	16 - GPIO23
3.3V Power - 17	18 - GPIO24
MOSI - GPIO10 - 19	20 - Ground
MISO - GPIO09 - 21	22 - GPIO25
SCLK - GPIO11 - 23	24 - GPIO8 - CE0
Ground - 25	26 - GPIO7 - CE1
SD - 27	28 - SC
GPIO05 - 29	30 - Ground
GPIO06 - 31	32 - GPIO12
GPIO13 - 33	34 - Ground
GPIO19 - 35	36 - GPIO16
GPIO26 - 37	38 - GPIO20
Ground - 39	40 - GPIO21










```
1  msg.payload={"temperature1":{"value":msg.payload , "type":"Float"}};
2  return msg;
```

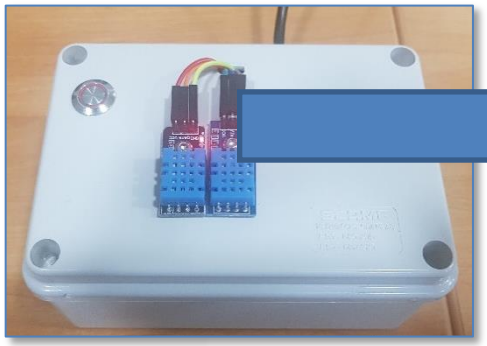
Snap4City on Raspberry Pi, IOT edge

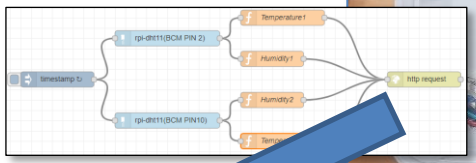
IOT Edge Computing

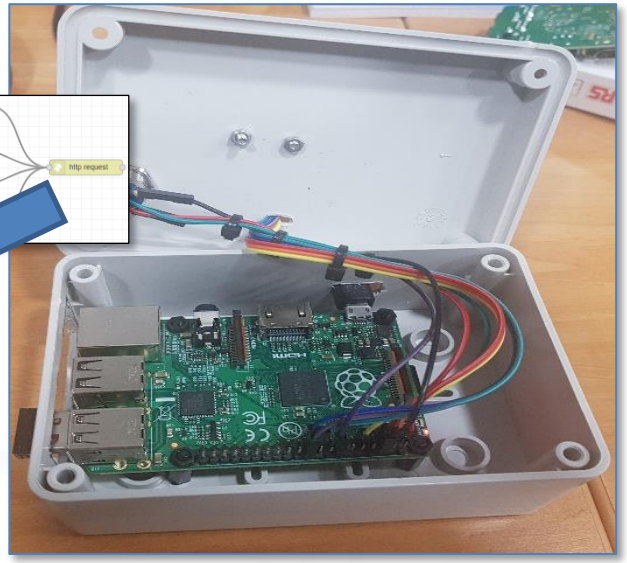
City user

Would like to:

- **Monitor and exploit temperature and humidity**
- **Manage sensors**
- **Perform edge computing**
- **Using these data for multiple applications**





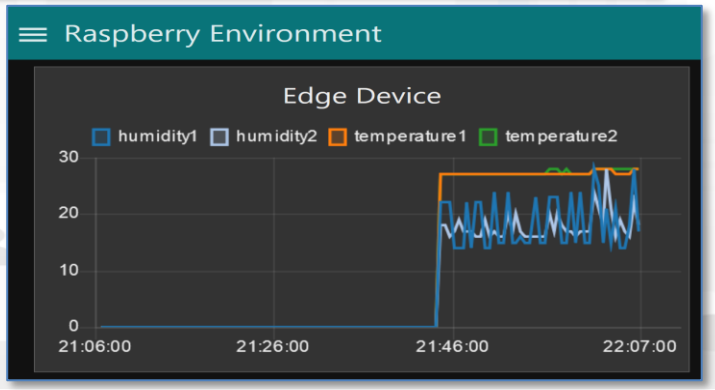


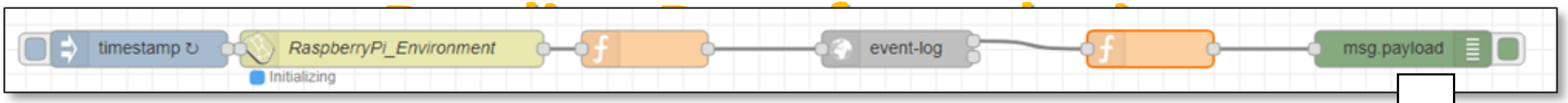
IOT Broker

Click here

Steps:

1. **Registering the device and sensors**
2. **Create flow on edge device using NodeRed with Snap4City, sending data to Broker**
3. **Use data from Broker on Snap4City IOT App**






```
19/3/2018, 22:20:48   node: 1fc37579.28dbfb
msg.payload : string[459]
"[{"type":"EdgeDevice","id":"RaspberryPi_Environment","attributes":
[{"name":"geolocalization_lat","type":"Float","value":"43.798778"},
{"name":"geolocalization_lon","type":"Float","value":"11.253522"},
{"name":"humidity1","type":"Float","value":"30.00"},
{"name":"humidity2","type":"Float","value":"33.00"},
{"name":"model","type":"String","value":""},
{"name":"temperature1","type":"Float","value":"26.00"},
{"name":"temperature2","type":"Float","value":"26.00"}]}]"
19/3/2018, 22:21:02   node: 1fc37579.28dbfb
msg.payload : string[459]
"[{"type":"EdgeDevice","id":"RaspberryPi_Environment","attributes":
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{"name":"geolocalization_lon","type":"Float","value":"11.253522"},
{"name":"humidity1","type":"Float","value":"30.00"},
{"name":"humidity2","type":"Float","value":"35.00"},
{"name":"model","type":"String","value":""},
{"name":"temperature1","type":"Float","value":"26.00"},
{"name":"temperature2","type":"Float","value":"26.00"}]}]"
19/3/2018, 22:21:08   node: 1fc37579.28dbfb
msg.payload : string[459]
"[{"type":"EdgeDevice","id":"RaspberryPi_Environment","attributes":
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{"name":"temperature2","type":"Float","value":"26.00"}]}]"
19/3/2018, 22:21:20   node: 1fc37579.28dbfb
msg.payload : string[459]
"[{"type":"EdgeDevice","id":"RaspberryPi_Environment","attributes":
[{"name":"geolocalization_lat","type":"Float","value":"43.798778"},
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{"name":"humidity1","type":"Float","value":"30.00"},
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{"name":"model","type":"String","value":""},
{"name":"temperature1","type":"Float","value":"26.00"},
{"name":"temperature2","type":"Float","value":"26.00"}]}]"
```
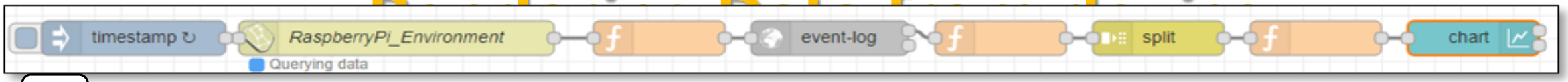
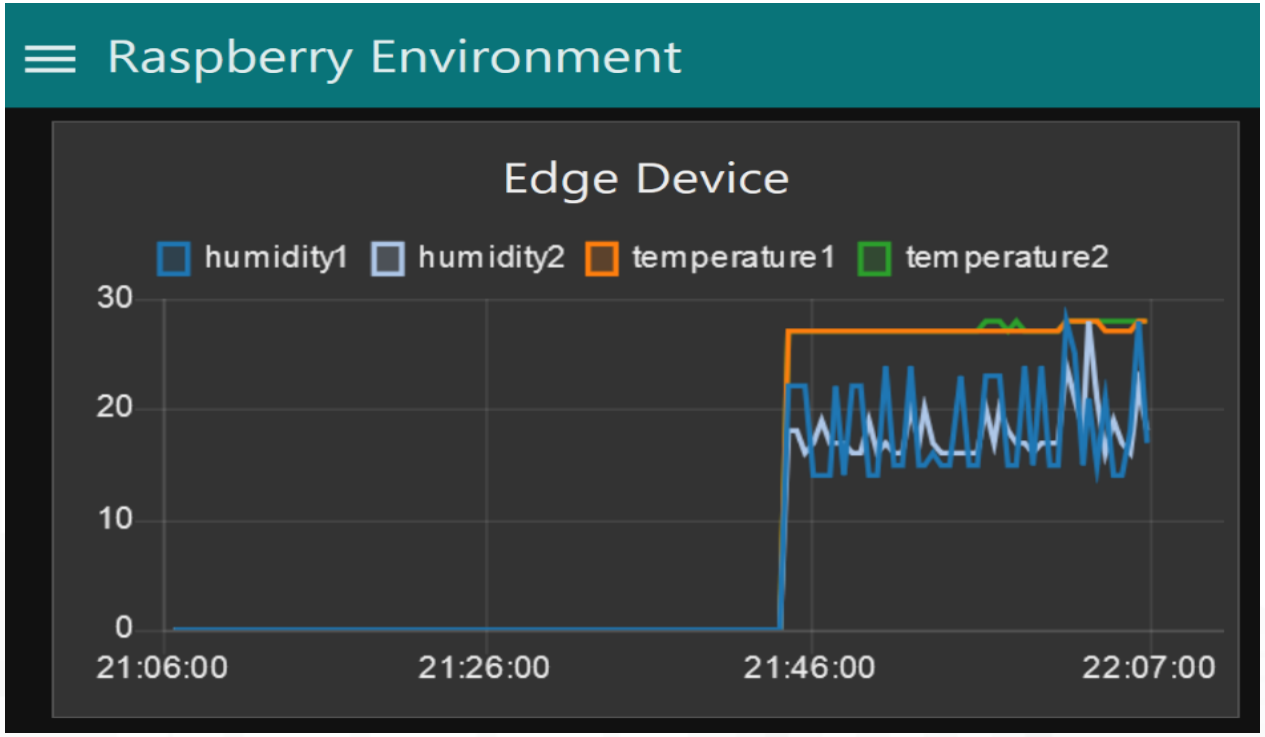
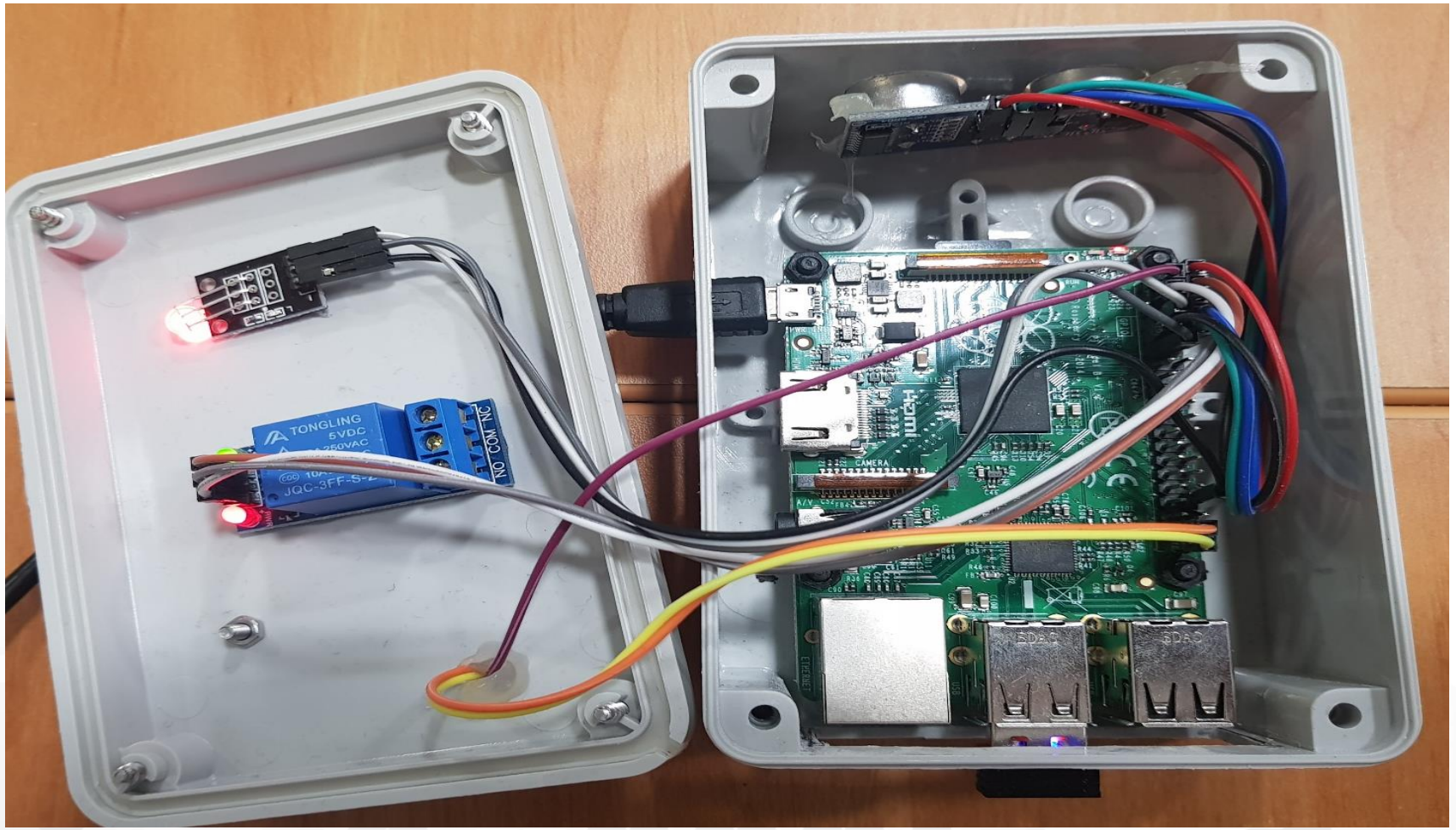


timestamp
RaspberryPi_Environment
Querying data
event-log
split
chart

a

b

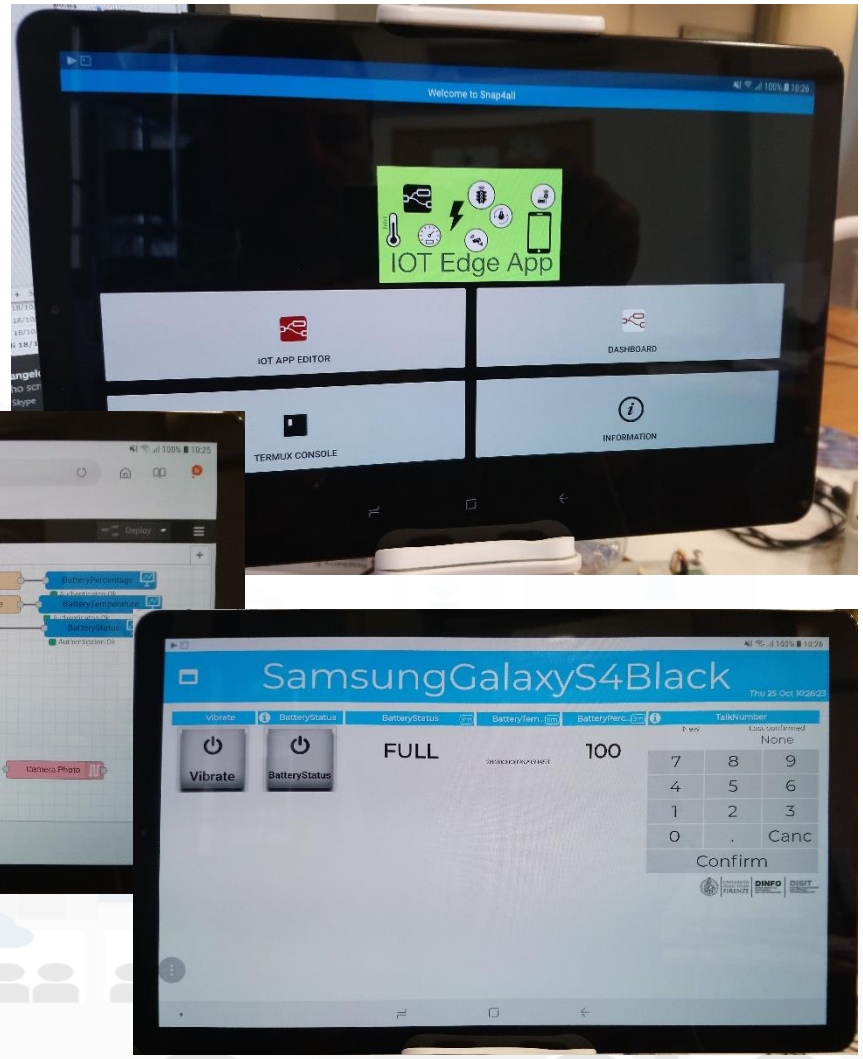

Raspberry Environment
Edge Device
humidity1
humidity2
temperature1
temperature2
30
20
10
0
21:06:00
21:26:00
21:46:00
22:07:00

Altro device: distanza, temperatura, attuazione



IOT Edge Snap4All App for Android

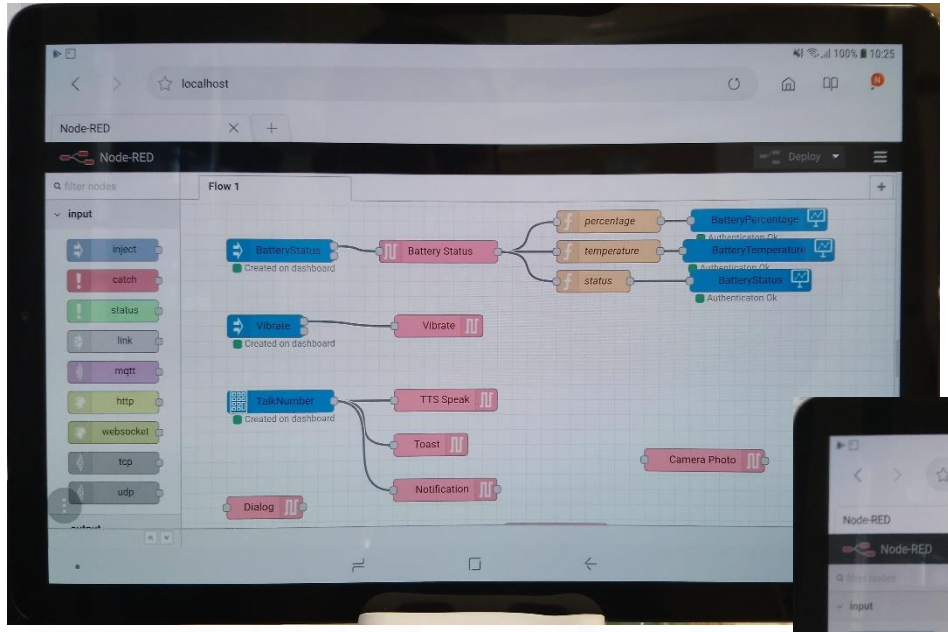
- **Android**, any version, App from: https://www.snap4city.org/download/video/Snap4All.apk
- **Mutual Authentication** with certificates
- *Secure encrypted connection*, NGSI
- **IOT Application inside**
- **Any sensor** + Local device sensors
- **Any protocol** from IOT devices
- **NGSI** or any other protocol
- **Fully Customizable**
- Local and Cloud Dashboard
- **Special MicroServices**

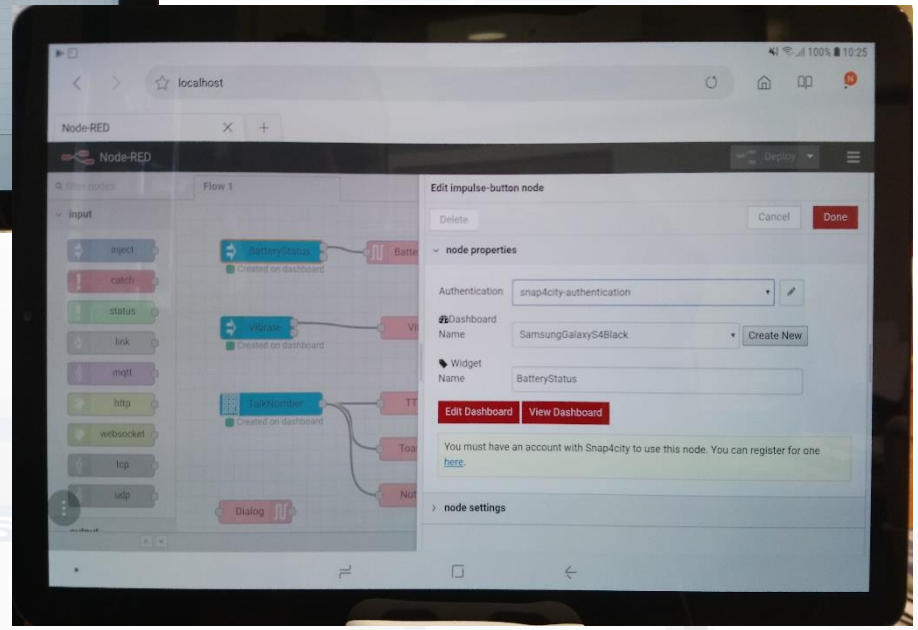


https://www.snap4city.org/drupal/node/278

IOT Edge Snap4All App for Android

- termux-battery-status
- termux-camera-info
- termux-clipboard-get
- termux-contact-list
- termux-telephony-cellinfo
- termux-telephony-deviceinfo
- termux-tts-engines
- termux-camera-photo
- termux-clipboard-set
- termux-dialog
- termux-download
- termux-location
- termux-tts-speak
- termux-vibrate
- termux-sms-inbox
- termux-toast
- termux-sms-send
- termux-share
- termux-notification
- termux-wifi-connectioninfo
- termux-wifi-scaninfo

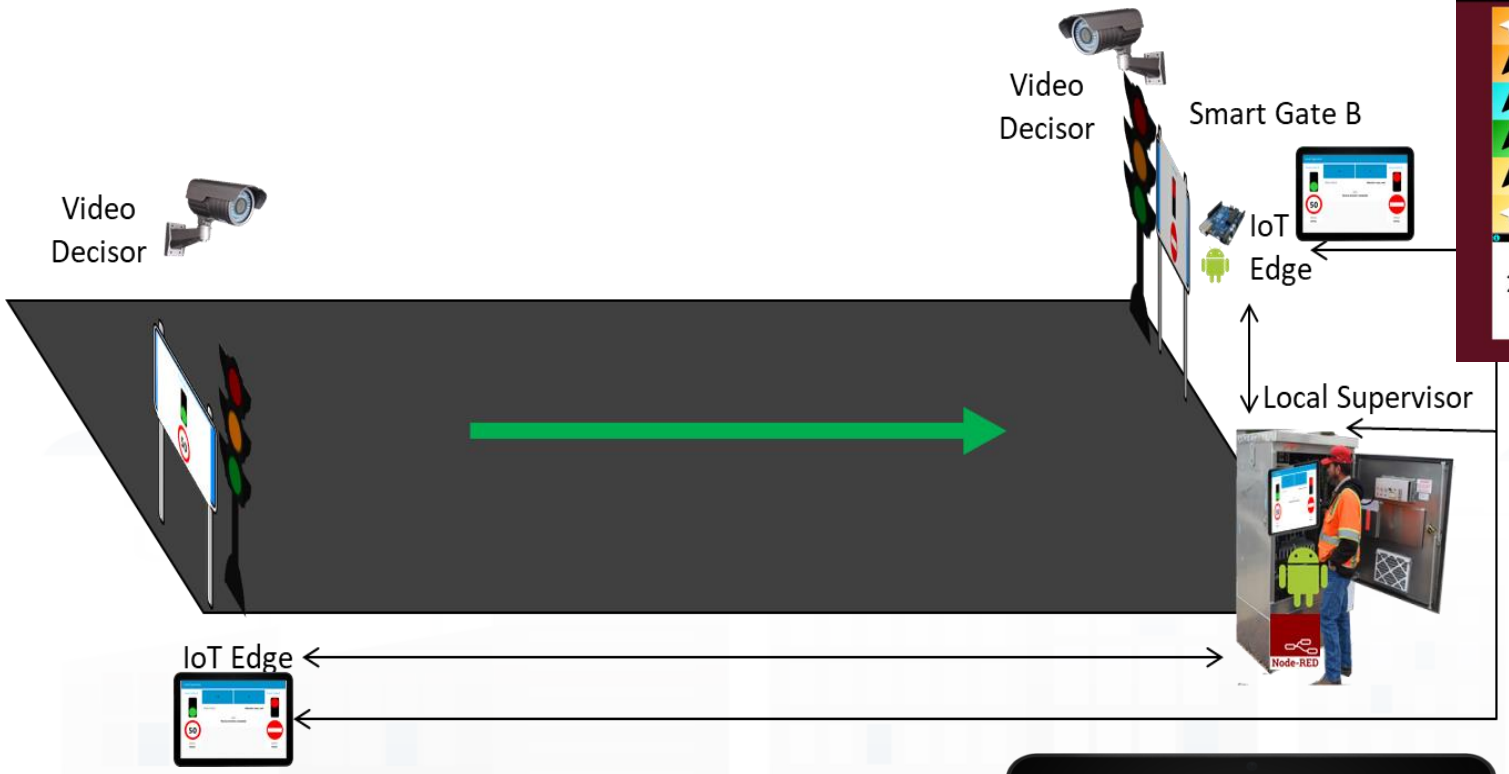


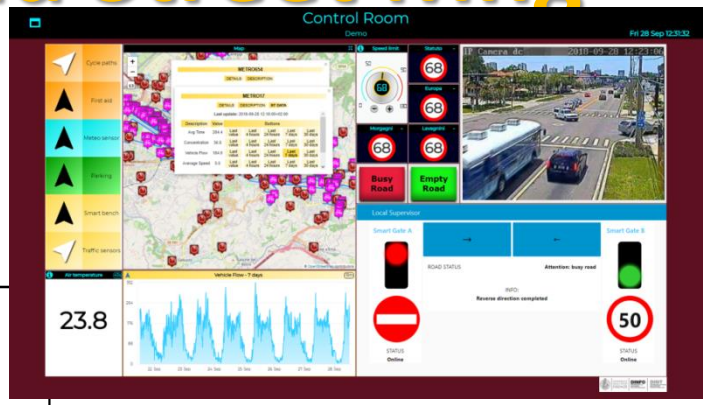


MicroServices:

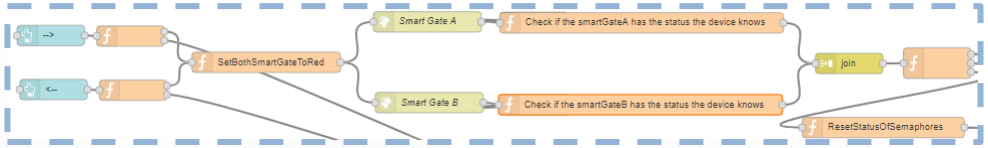
- Snap4City
- Termux Snap4City specific
- etc.

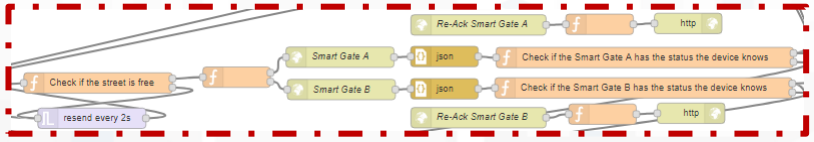
Sii-Mobility: Dynamic Signage and Street Mng

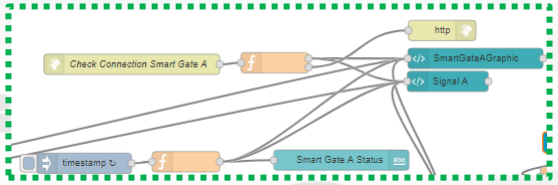




Control Room





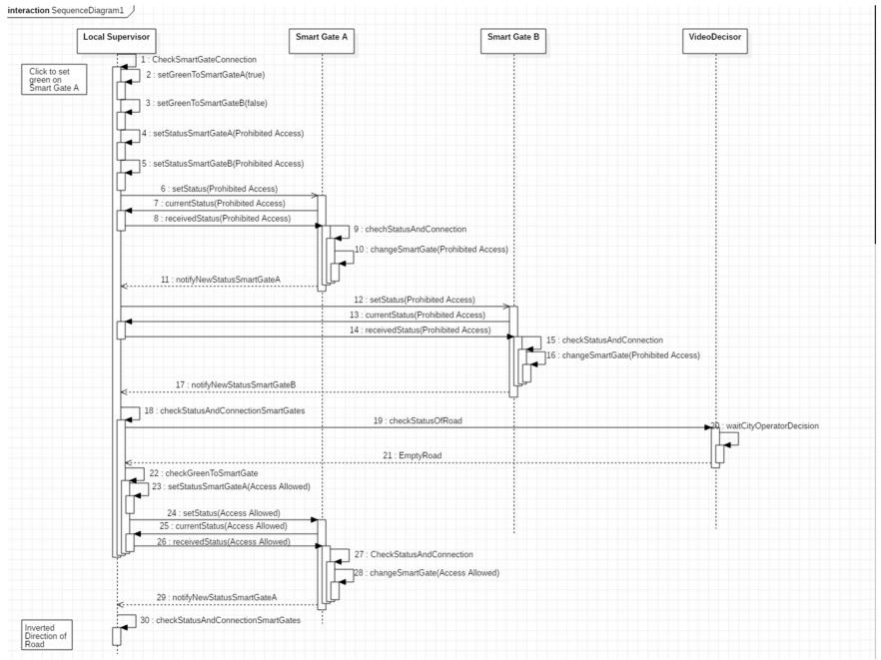


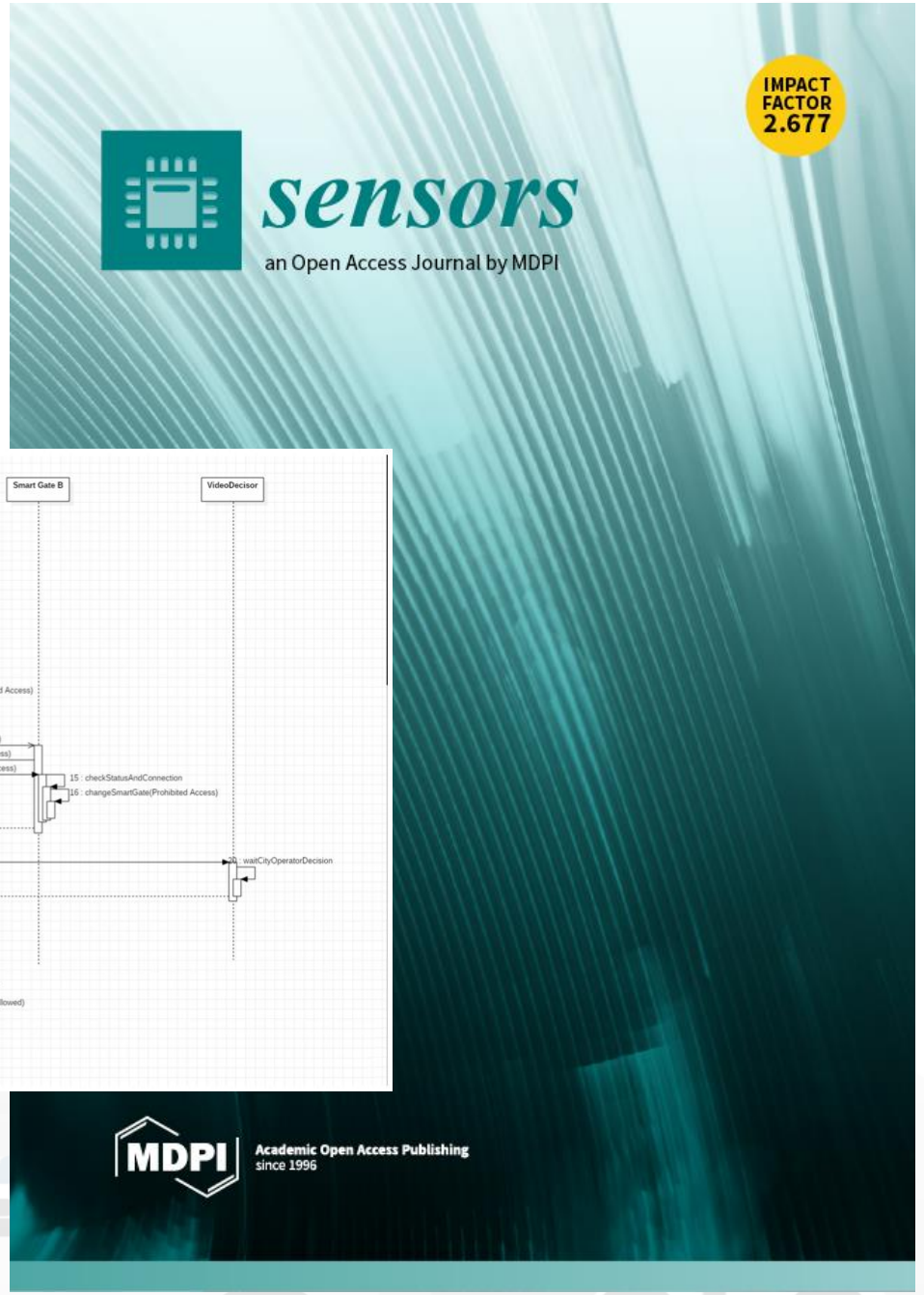
Local Control Dashboard

Safe and resilient solution manging Degradated conditions

IOT for Mobility Infrastructure

- C. Badii, P. Bellini, A. Difino, P. Nesi, "*Sii-Mobility: an IOT/IOE architecture to enhance smart city services of mobility and transportation*", Sensors, MDPI, 2019
- https://www.mdpi.com/1424-8220/19/1/1/pdf





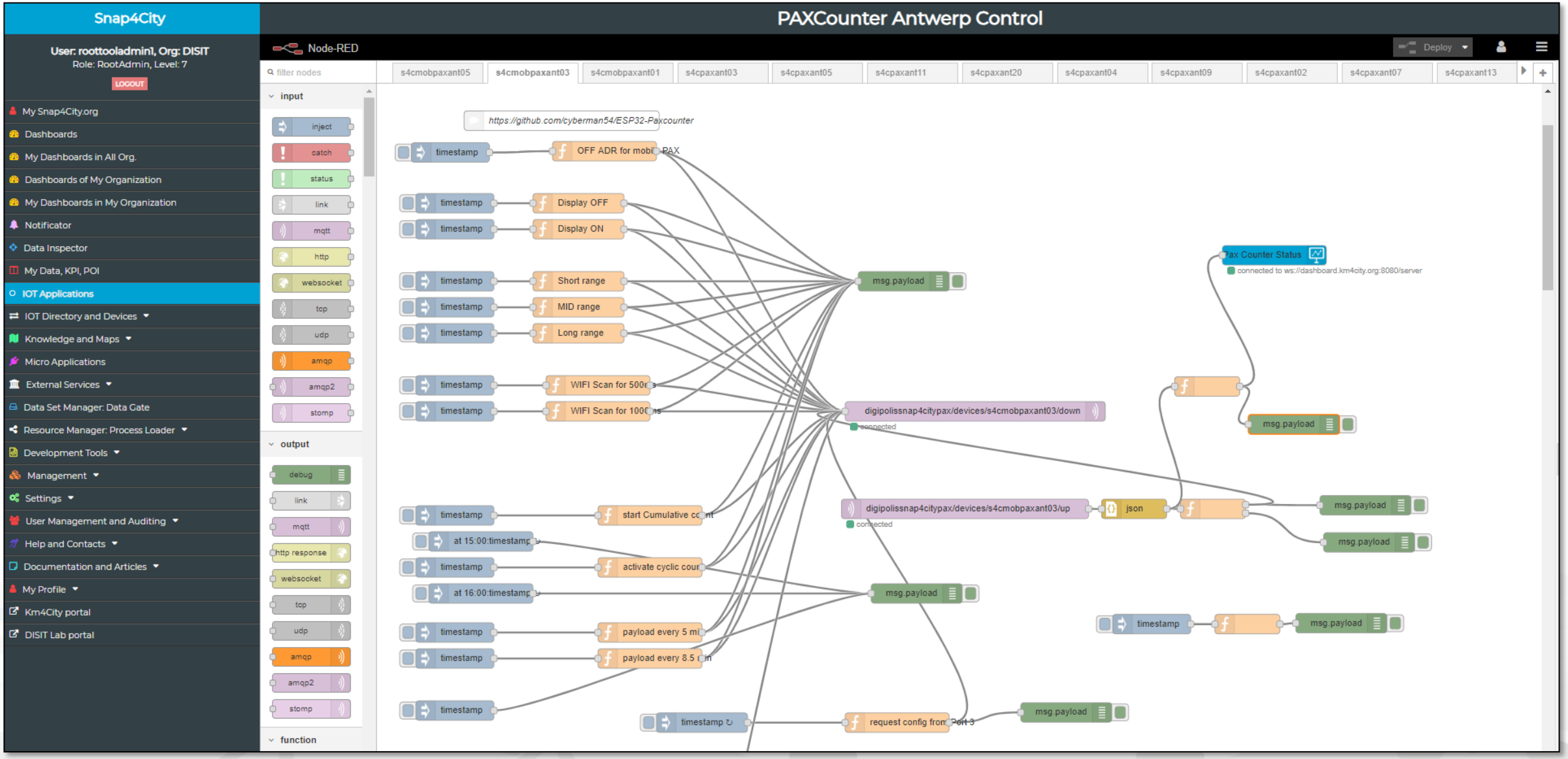
PaxCounter devices

- Fixed PaxCounter LoraWan
  - Based on Wi-Fi- Bluetooth
- Mobile PaxCounter LoraWan
  - Based on Wi-Fi- Bluetooth
- Fixed PaxCounter(LoraWan+Wifi out)
  - Based on Wi-Fi- Bluetooth

https://www.snap4city.org/drupal/node/456

Programmable PAX counting

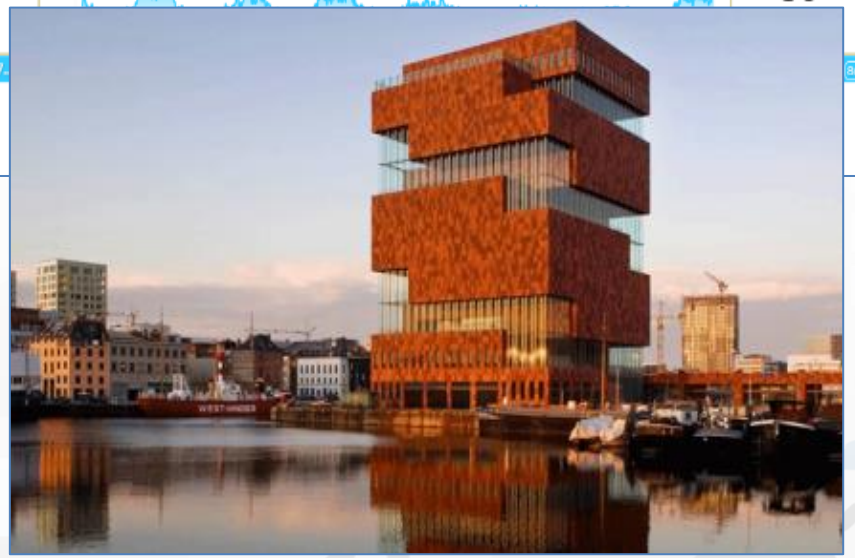
Iot app behind



PAXCounter real time and trend

Mon 30 Sep 17:18:48

s4cpaxant01	3	s4cpaxant11	72
s4cpaxant02	1157	s4cpaxant12	15
s4cpaxant03	17	s4cpaxant13	295
s4cpaxant04	7	s4cpaxant14	13
s4cpaxant05	4	s4cpaxant15	59
s4cpaxant06	17	s4cpaxant16	30
s4cpaxant07	952		



SNAP4CITY

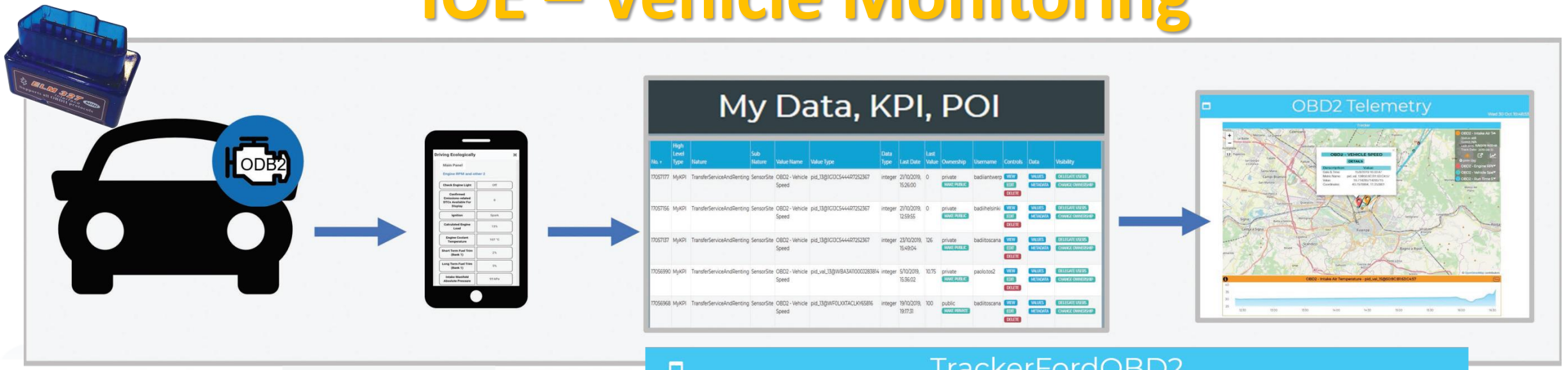
KM4CITY

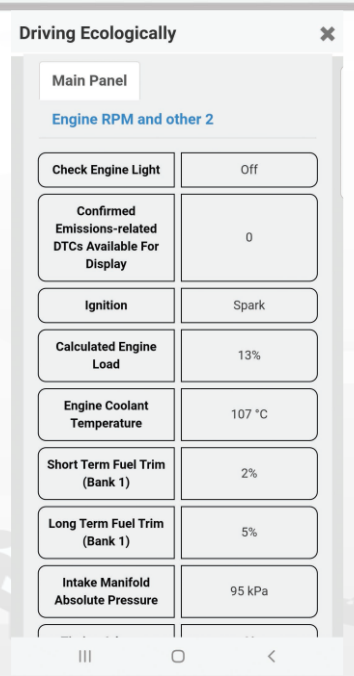
MAS Monitoring via PAXCounter

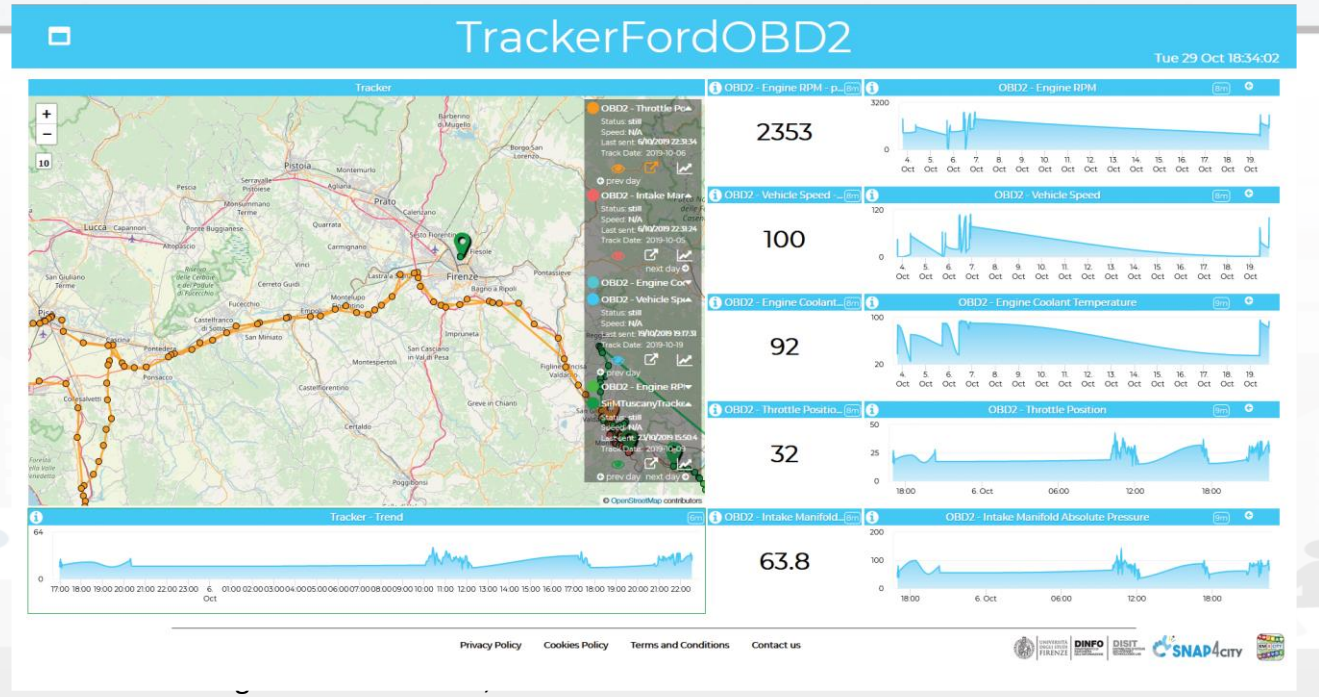
Mon 30 Sep 17:31:32

pax03 in	17	s4cpaxant03 - ingang gelijkvloers balie	s4cpaxant03 - wifi / s4cpaxant03delta - wifi
pax05 8ste	9	s4cpaxant05 - 8ste verdieping, ingang	s4cpaxant05 - 8ste ingang H24 / s4cpaxant05 change on passages
pax20 2de	13	s4cpaxant20 - 2de verdieping, uitgang	s4cpaxant20 - 2de uitgang H24 / s4cpaxant20delta - change on passages
pax11 4de	74	s4cpaxant11 - 4de verdieping, uitgang	s4cpaxant11 - 4de uitgang H24 / s4cpaxant11delta - change on passages

IOE – Vehicle Monitoring







Capabilities

- **Creating IOT Applications for:**
  - **Controlling industrial/local processes** locally and globally
  - **Exploiting IOT Edge for local IOT Applications**
    - Local smartness, limited computational capabilities, limited dashboarding
    - Resilience wrt lack of power and connectivity: autonomous
  - **Sending data on Cloud** via secure connection and for:
    - business intelligence, data analytics, machine learning
    - Global scale and local scale analytics
    - Dashboarding at global scale
    - remote control and actions on industrial processes
    - Logging of the activities

IOT Devices and IOT Edge (Self Training)

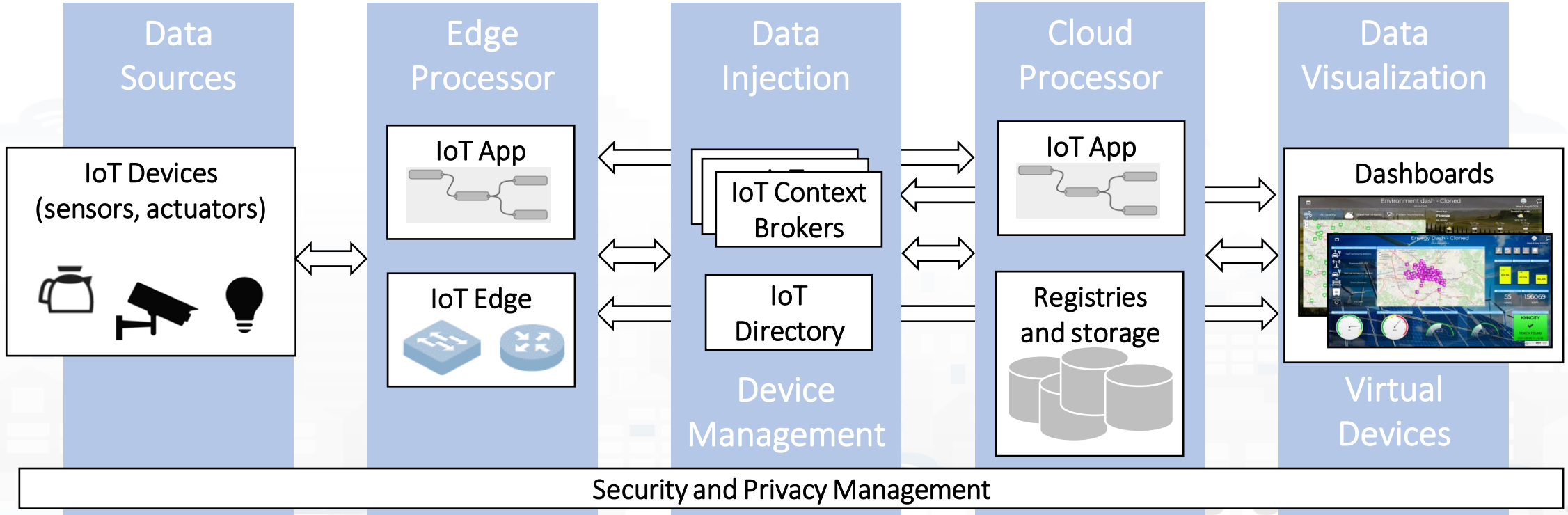
- **A large range of Devices** can be used on Snap4City:
  - Proprietary or Open HW/SW.
  - Devices of/for makers on which we provide Open source code
- **Documentation and instructions:**
  - TC9.4 - IOT application exploiting Edge computing with Raspberry
  - TC9.7 - Connection from LoraWan Dragino/arduino to Orion broker
  - Snap4City: Arduino & ESP8266 IOT Device NGSI
  - Snap4City IOT Devices Registration
  - Snap4All IOT Button: based on ESP32, NGSI compliant secure connection
  - IDE Setup for Snap4All IOT Button, and source code
  - Registering IOT Edge: example of Raspberry Pi, total security
  - Creating: IOT Device, Raspberry Pi based, totally compliant with Snap4City

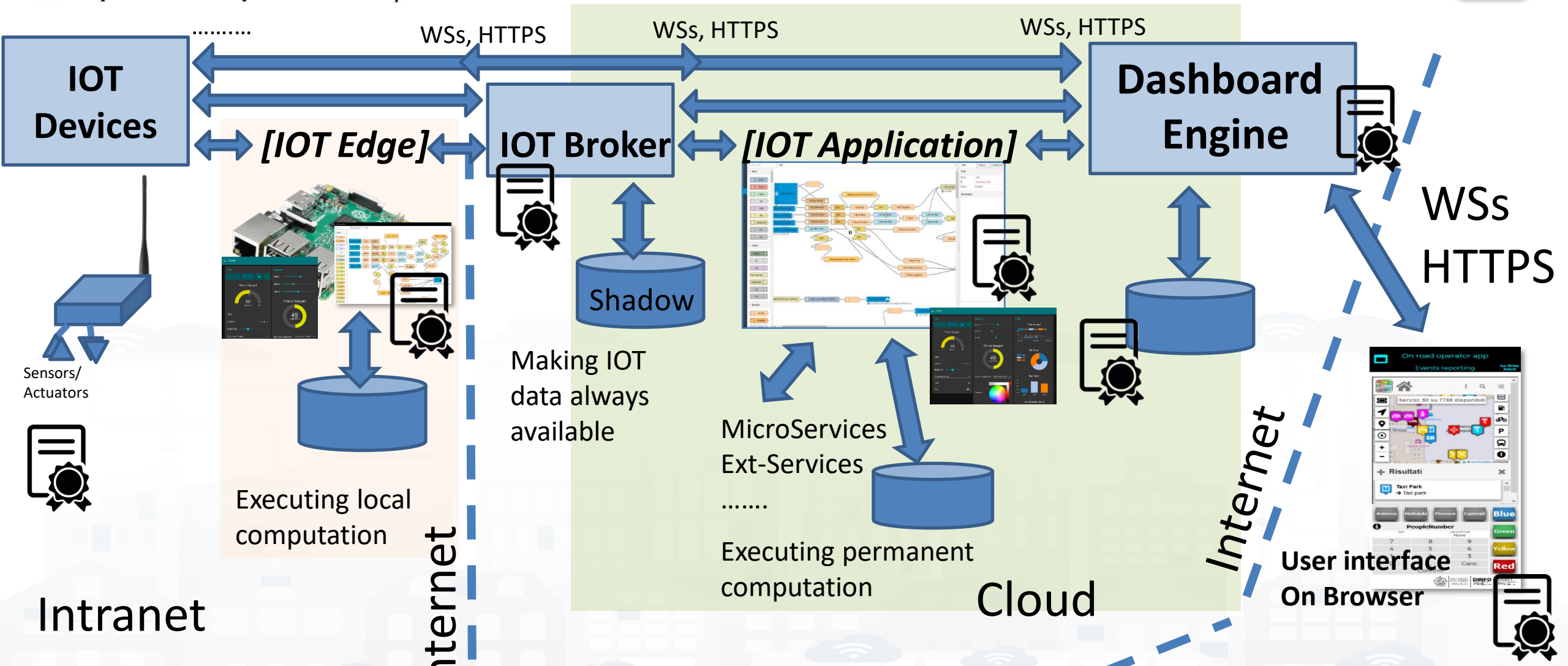
End-to-end security on IOT infrastructures

Complexity in Smart City IOT Platforms

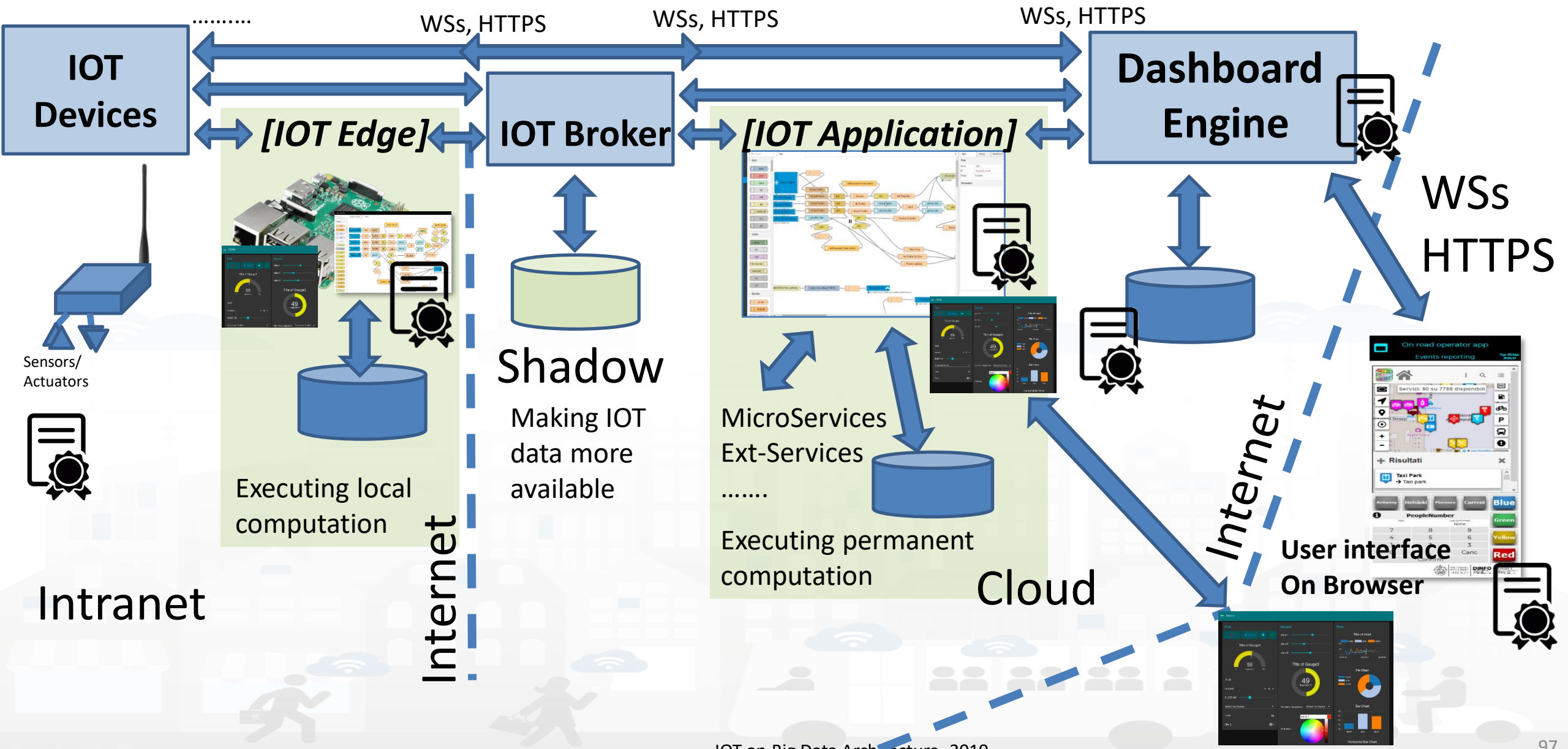
End to End security

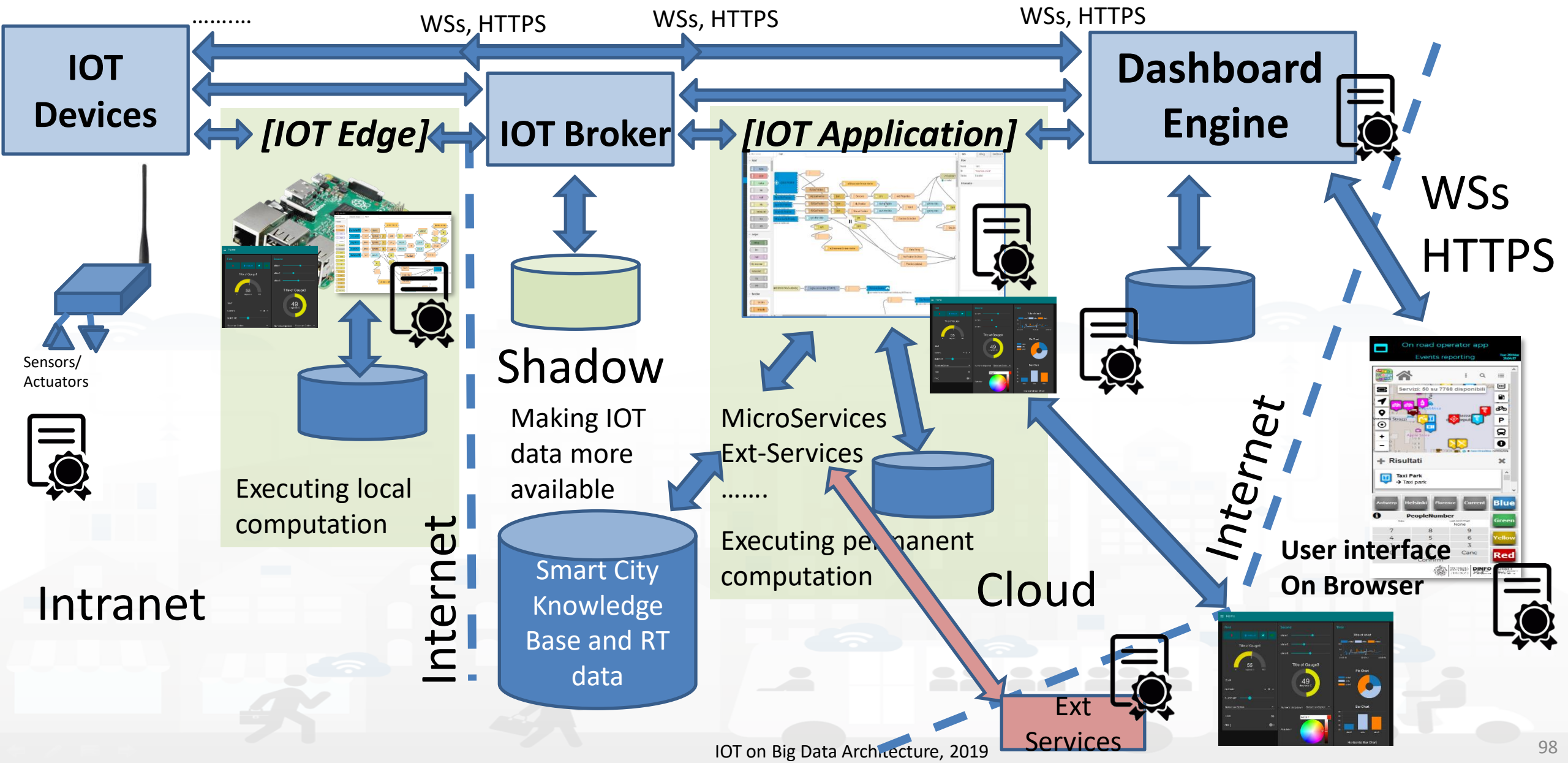
– From IOT Devices to Dashboard (user interface)





End 2 end security


.....
WSs, HTTPS
WSs, HTTPS
WSs, HTTPS
IOT Devices
[IOT Edge]
IOT Broker
[IOT Application]
Dashboard Engine
WSs
HTTPS
Sensors/
Actuators
Executing local computation
Shadow
Making IOT data more available
MicroServices
Ext-Services
.....
Executing permanent computation
Internet
Internet
Intranet
Cloud
User interface
On Browser


.....
WSs, HTTPS
WSs, HTTPS
WSs, HTTPS
IOT Devices
[IOT Edge]
IOT Broker
[IOT Application]
Dashboard Engine
WSs
HTTPS
Sensors/
Actuators
Executing local computation
Shadow
Making IOT data more available
MicroServices
Ext-Services
.....
Executing permanent computation
Internet
Smart City Knowledge Base and RT data
Cloud
Internet
User interface On Browser
Ext Services
Intranet

Grouping on Data Lake

IOT Devices

.....

WSs, HTTPS

WSs, HTTPS

WSs, HTTPS

Dashboard Engine

[IOT Edge]

IOT Broker

[IOT Application]

WSs HTTPS

Sensors/ Actuators

Executing local computation

Shadow

Making IOT data more available

MicroServices
Ext-Services
.....

Executing permanent computation

Internet

Smart City Knowledge Base and RT data

Cloud

Internet

User interface On Browser

Ext Services

Intranet

Grouping on Data Lake

IOT Devices

.....

WSs, HTTPS

WSs, HTTPS

WSs, HTTPS

Dashboard Engine

[IOT Edge]

IOT Broker

[IOT Application]

Data Analytics

WSs HTTPS

Sensors/ Actuators

Executing local computation

Shadow

Making IOT data more available

MicroServices
Ext-Services
.....

Executing permanent computation

Intranet

Internet

Smart City Knowledge Base and RT data

Parallel Computing

Cloud

Ext Services

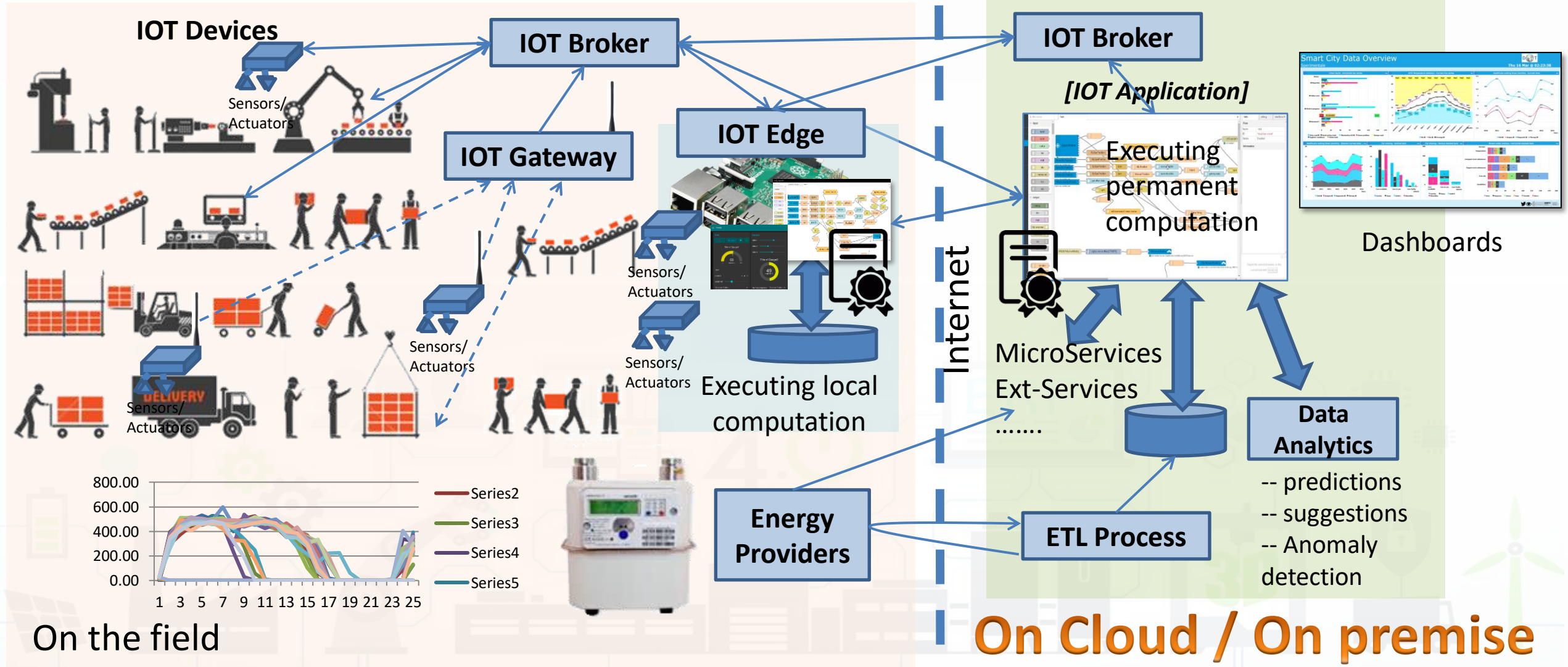
Internet

User interface On Browser

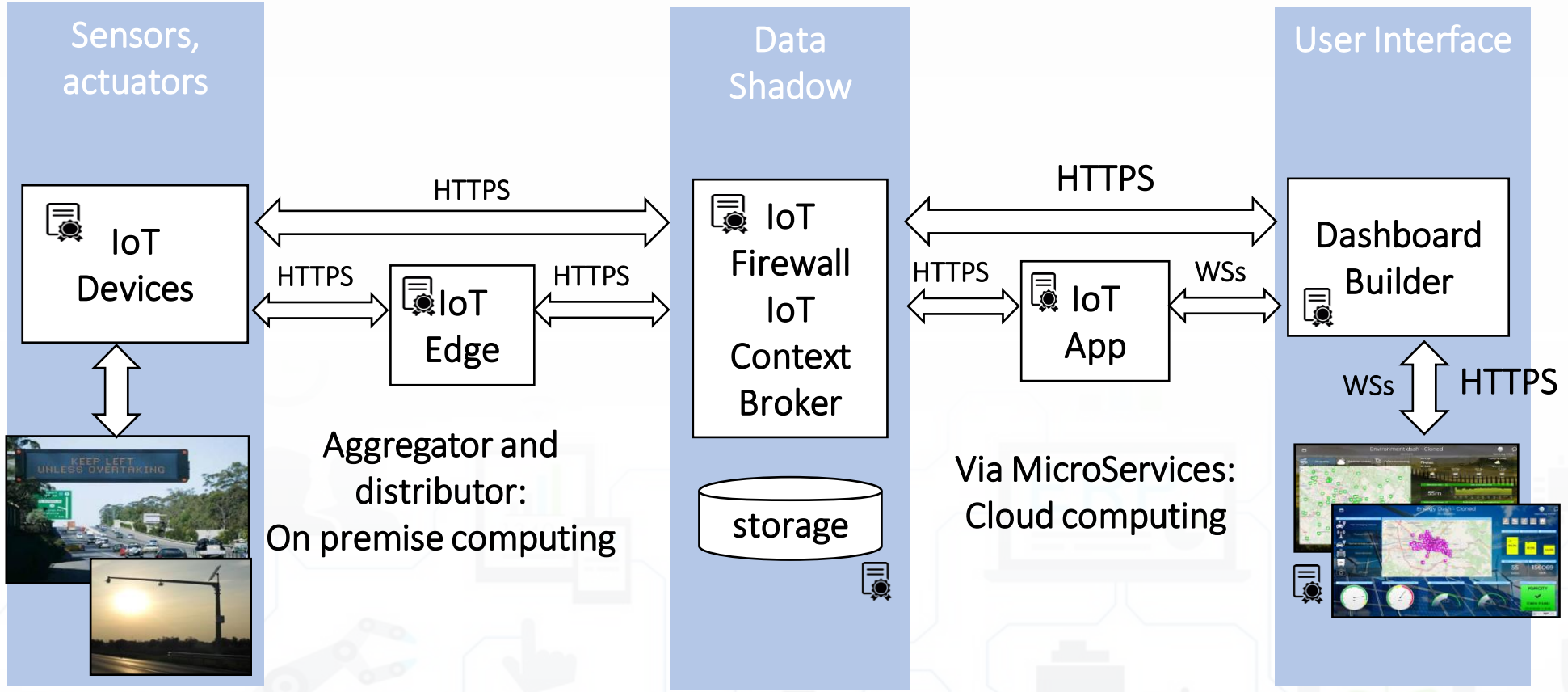
SNAP4APPLIANCE
Virtual Machines ready to use for Smart City and IOT Applications
DOWNLOAD

SNAP4INDUSTRY
KM4CITY

Industry 4.0 Application

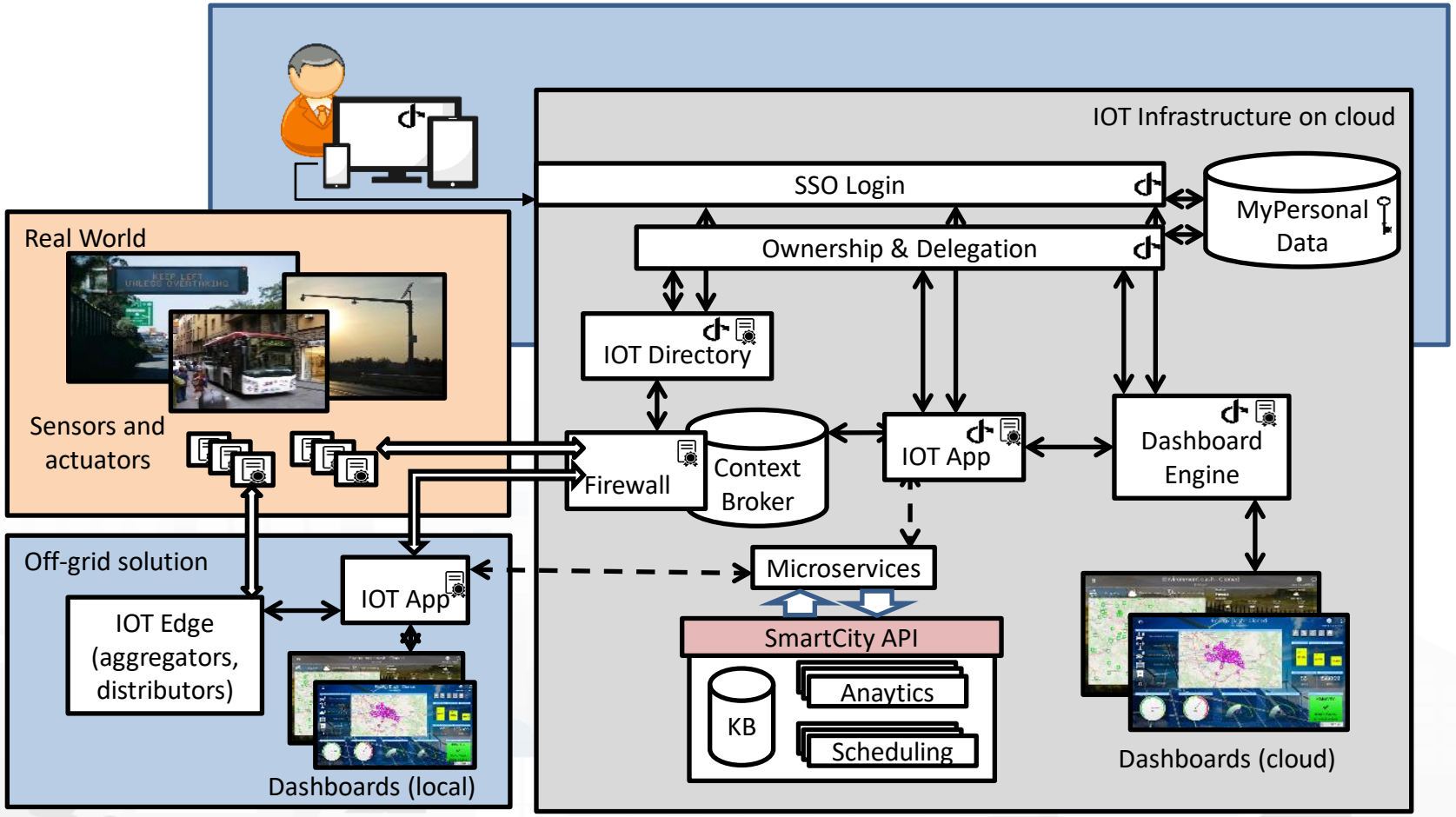


The secure stack



Snap4City Solution (User-Data)

- User data protection (by design)
  - Encryption on ***_any_*** personal data and storing in an isolated environment
    - Ownership and delegation (user access control and consent management)
    - Accessible remotely via APIS with authentication and authorization (LDAP and OpenIDconnect)
      - Description of user credentials Roles / Groups / Organization
      - In an encrypted way (TSL/SSL)
- Elapsing time (by default)
  - Deleting by temporally marking (investigative authorities audits)
- Tracking any activities → monitoring and auditing

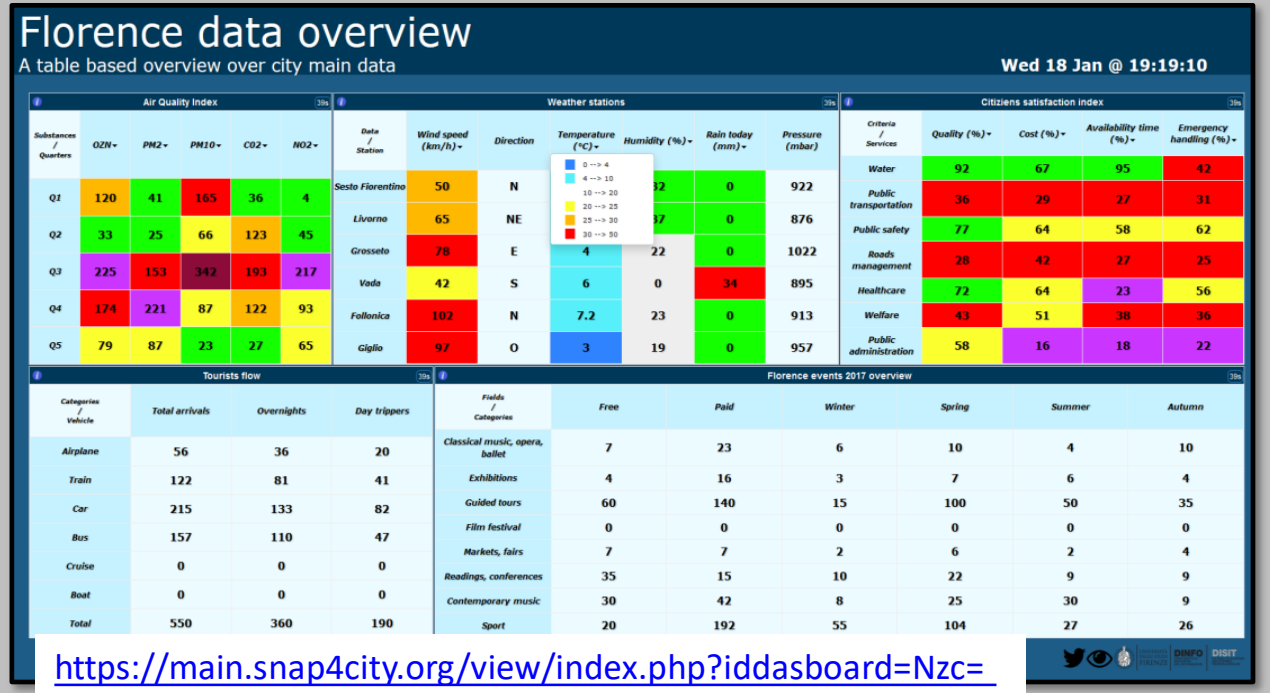


Establishing Protected connections

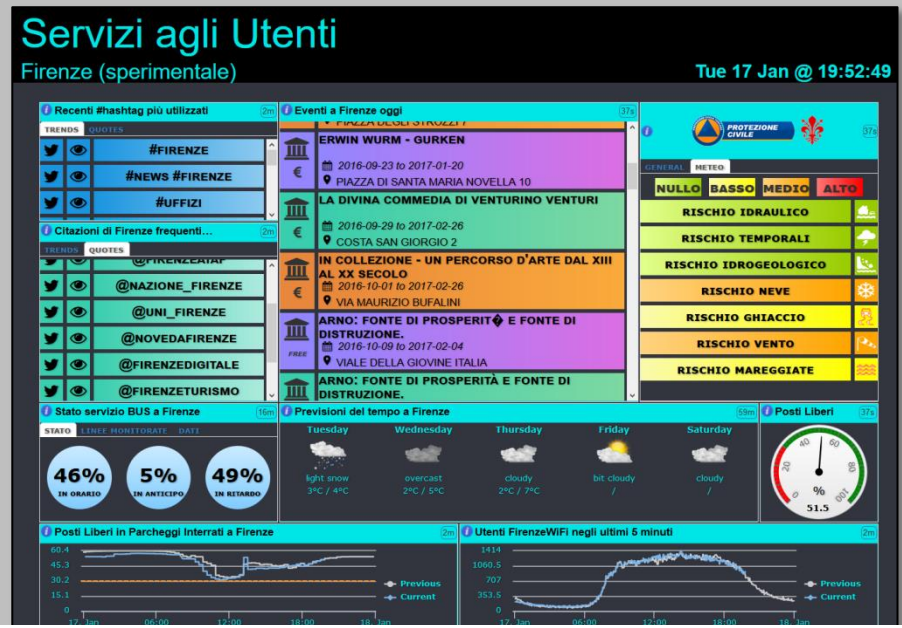
- For example:
  - From IOT Broker to IOT Applications: sending data
  - From IOT Applications to
    - IOT Brokers: registering, subscribing, sending, etc.
    - MyPersonalData: save and reload (key + personal data + personal KPI)
    - Dashboards
- etc.

Creation of Dashboards and Applications

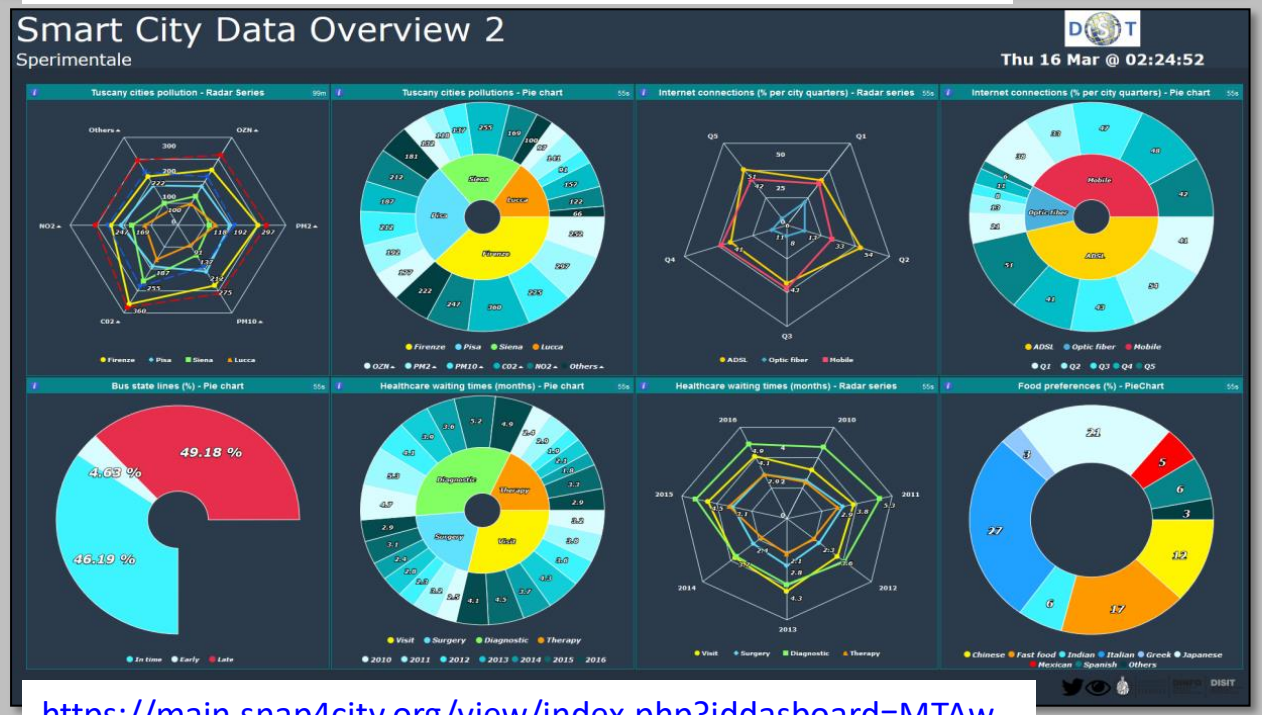
Datacenter Energy Consumption
DataCenter gas and smoke (mobile)
DISIT
Sat 22 Jun 09:40:02
Smoke1
6
Smoke1 (day)
Smoke2
3
Smoke2 (day)
Smoke3
4
Smoke3 (day)
Gas1
36
Current
Previous
Temperatures - Room of machine 166
DISIT
22.4
deg
Temperature 1 (last 12 hours)
Temperature 1 (H24)
20.4
deg
Temperature 2 (last 12 hours)
Temperature 2 (H24)
Humidity %1
31.5
Humidity Percentage 1 (daily)
Humidity %2
40.5
Humidity Percentage 2 (daily)
WebMonitoring major
Status of Web servers
Sat 22 Jun 09:43:50
DISIT_ORG
KM4CITY
SERVICEMAP
SERVICEMAPOSM
TWITTERVIGILANCE
LINKEDOPENGRAPH
NODERED_1
NODERED_2
NODERED_3
NODERED_4
NODERED_5
NODERED_6
NODERED_7
NODERED_8
TOKEN FOUND



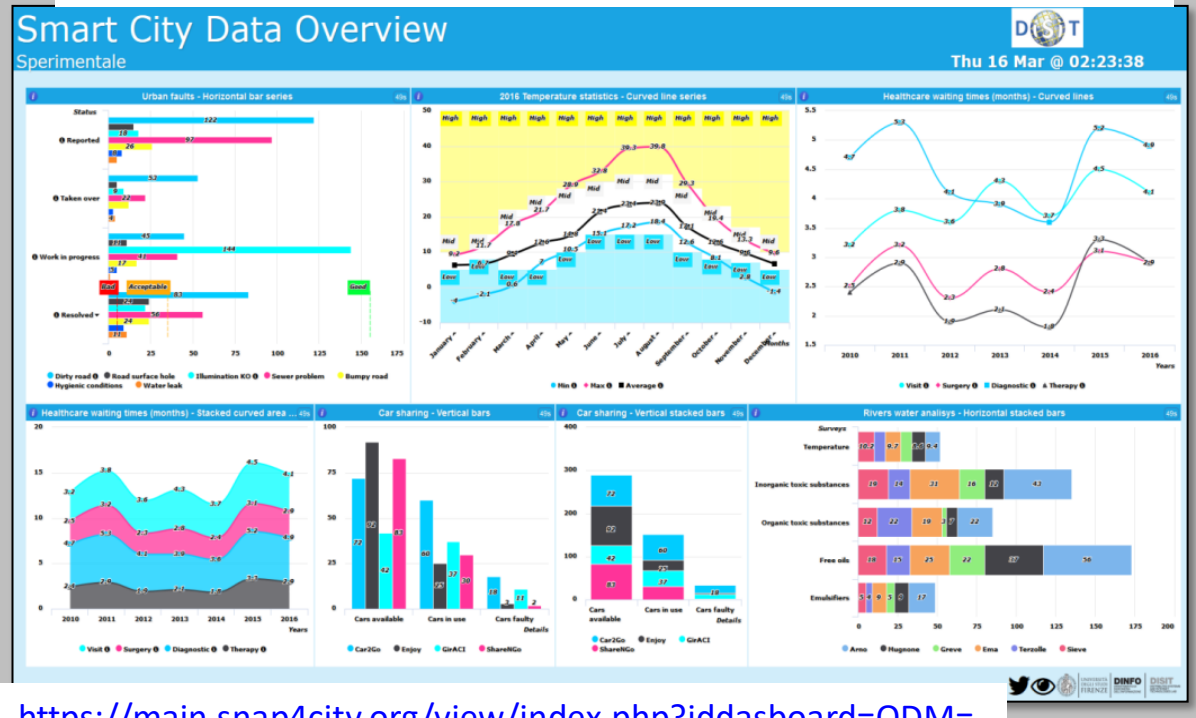
https://main.snap4city.org/view/index.php?iddasboard=Nzc=



https://main.snap4city.org/view/index.php?iddasboard=NjQ=



https://main.snap4city.org/view/index.php?iddasboard=MTAw



https://main.snap4city.org/view/index.php?iddasboard=ODM=

Altair
Monitoraggio Impianto
Wed 26 Sep 16:59:19
CL - Carrello
2
ppm
CL giornaliero - Carrello
005%
HCL - Carrello
5
ppm
HCL giornaliero - Carrello
09/26/2018
16:56:59
CL - Drone
0
ppm
CL giornaliero - Drone
45.778/center
HCL - Drone
0
ppm
NO_GPS

Chemical Plant Dashboard

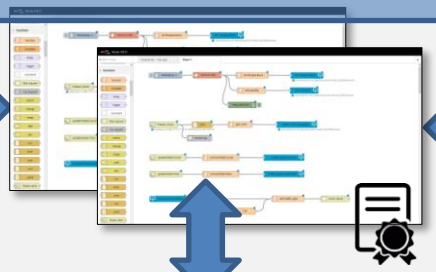
Green Impact Capacity (GIC)

Altair Control room

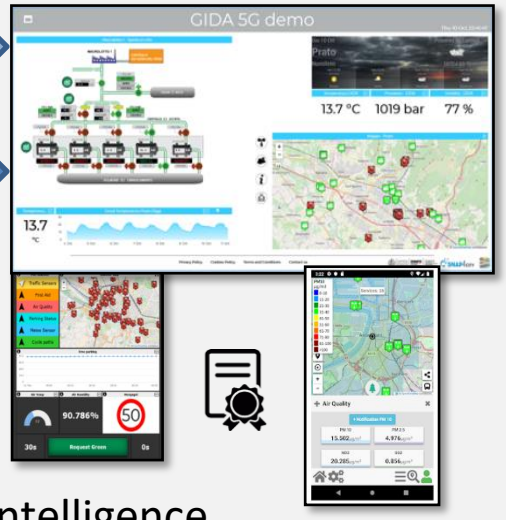
GIDA set up

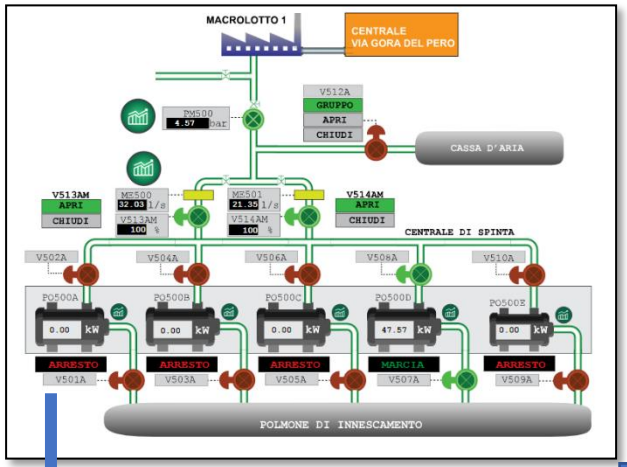
Smart City data from many sources

IOT Applications



Dashboards and Apps





IOT Data Shadow Snap4City

Big Data Analytics, Artificial Intelligence

ModBus to Snap4City Gateway Edge

5G network devices

Modbus

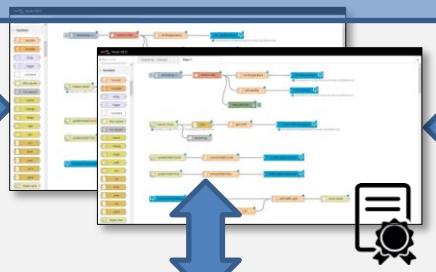
5G

open fiber WIND 3 ZTE

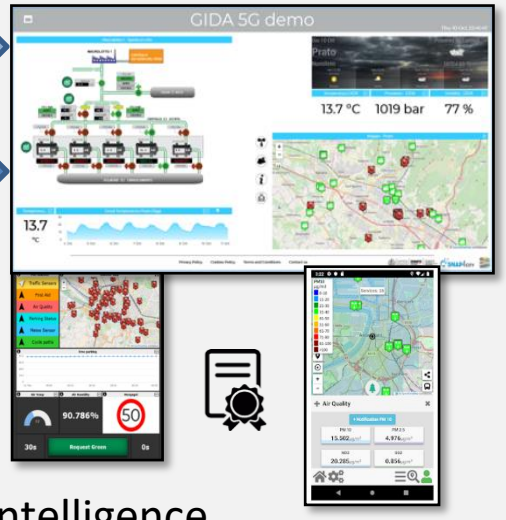
GIDA set up

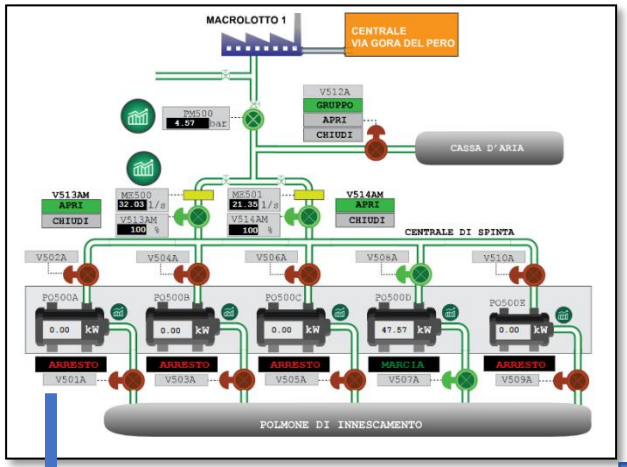
Smart City data from many sources

IOT Applications



Dashboards and Apps





IOT Data Shadow Snap4City

Big Data Analytics, Artificial Intelligence

ModBus to Snap4City Gateway Edge

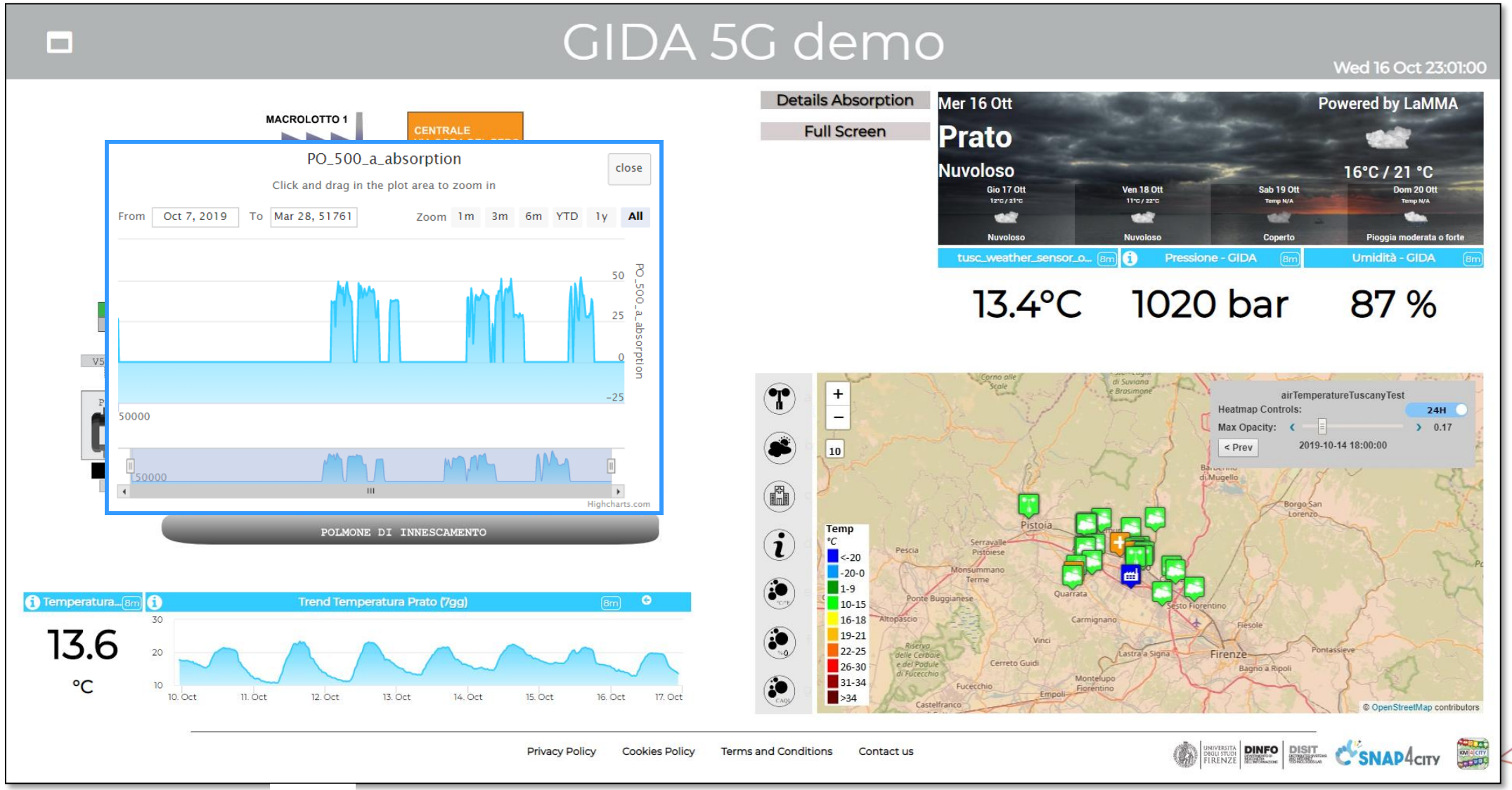
5G network devices

Modbus

5G

open fiber WIND 3 ZTE

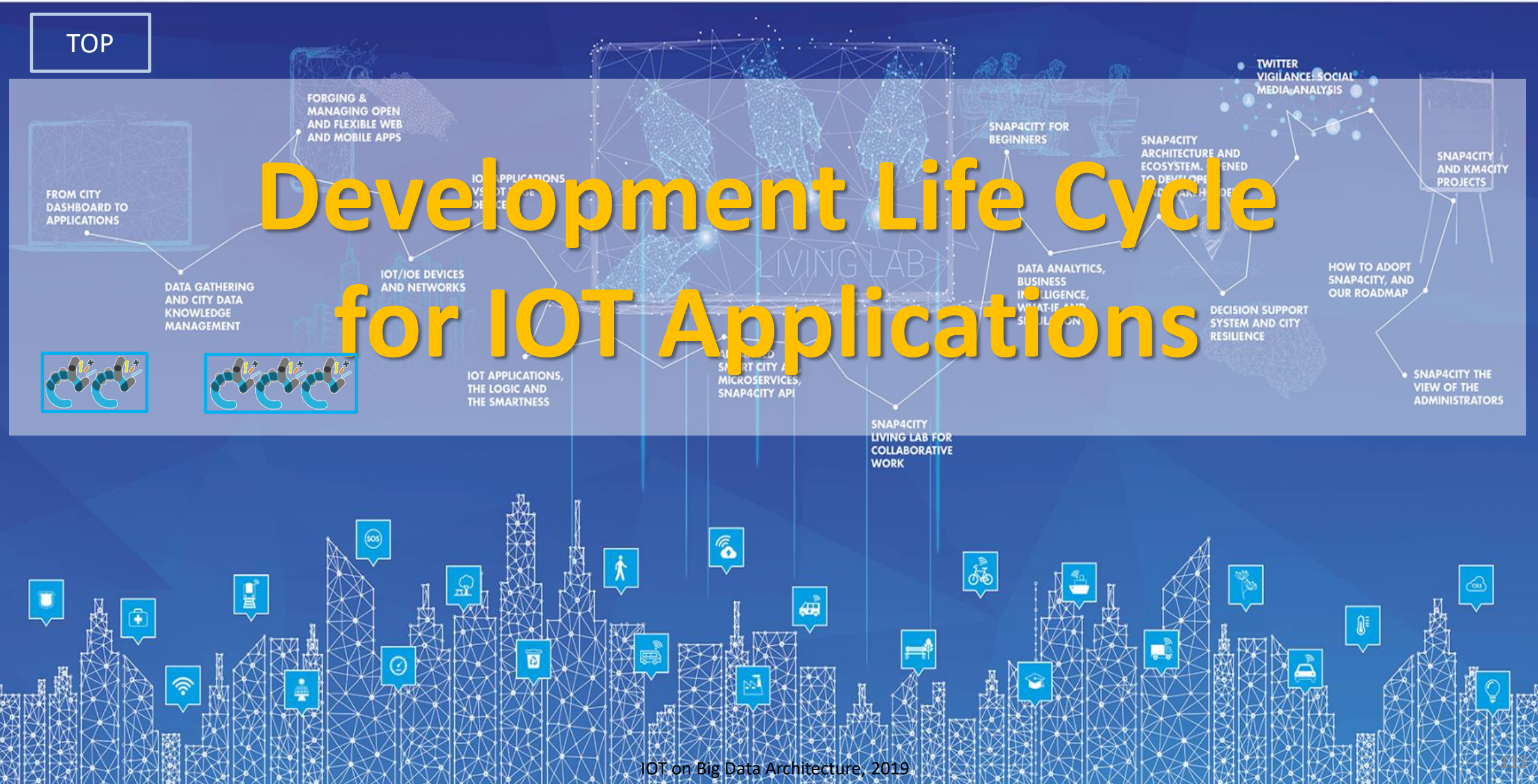
Demo UC5 GIDA



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjIyNg==

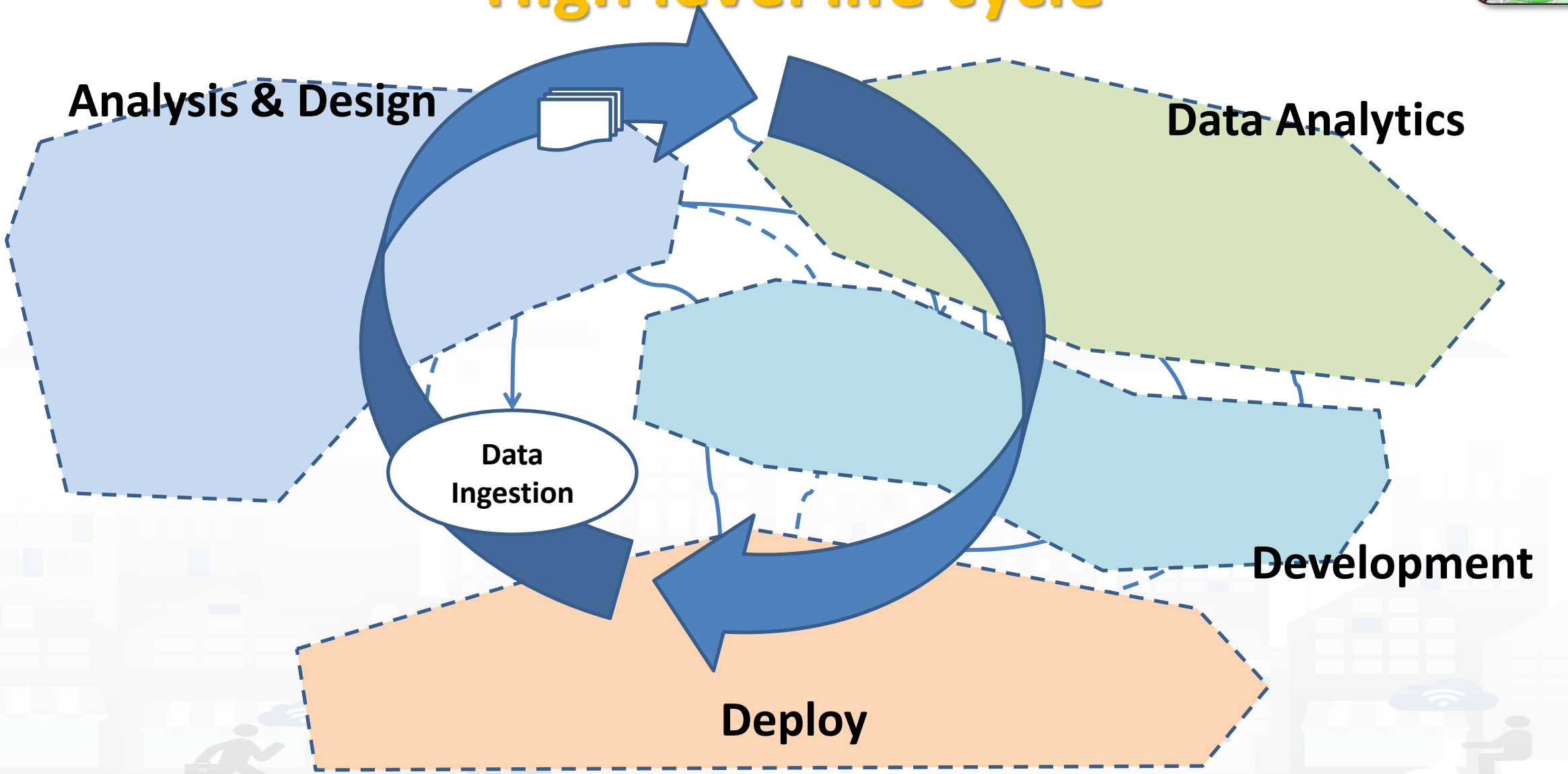
TOP

Development Life Cycle for IOT Applications

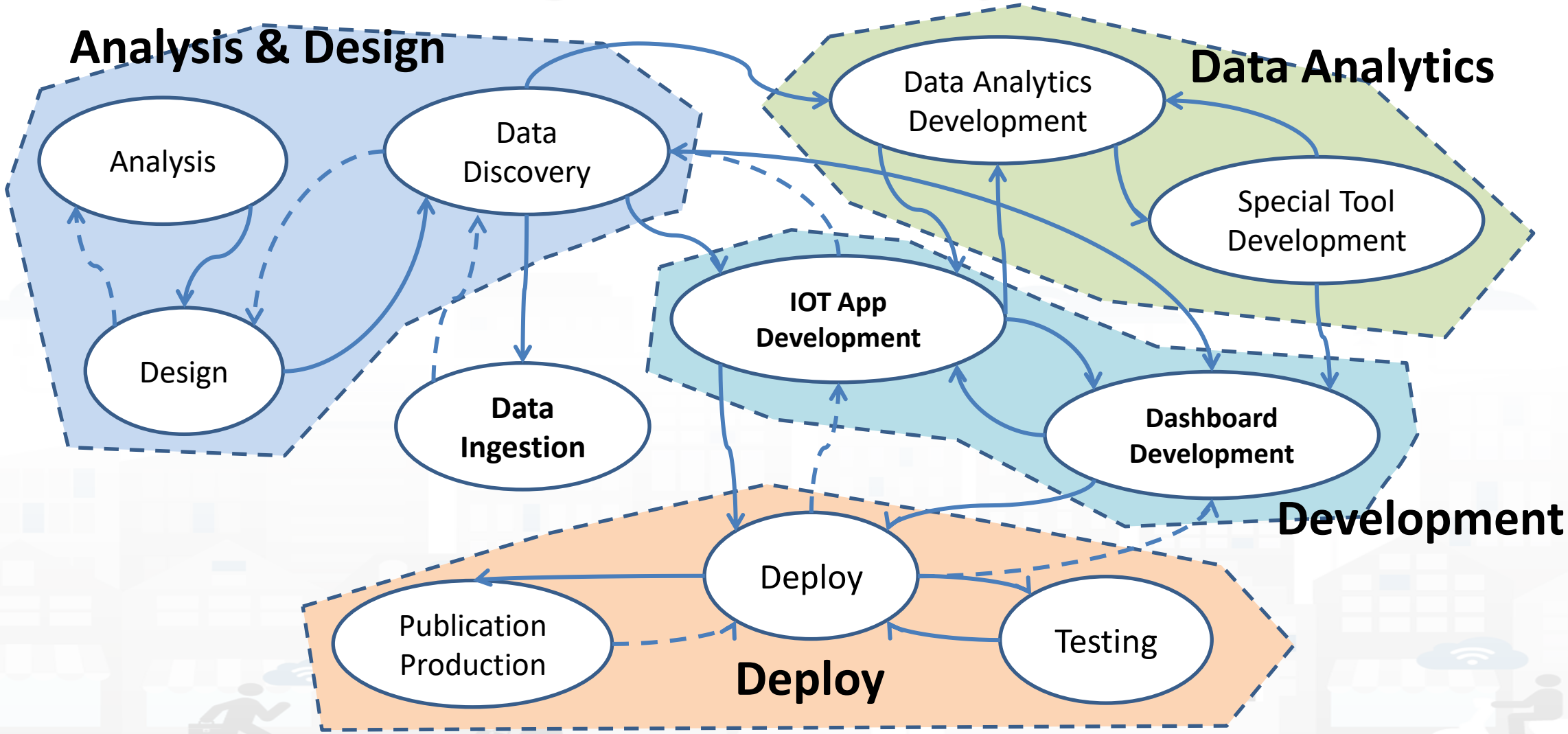


IOT on Big Data Architecture, 2019

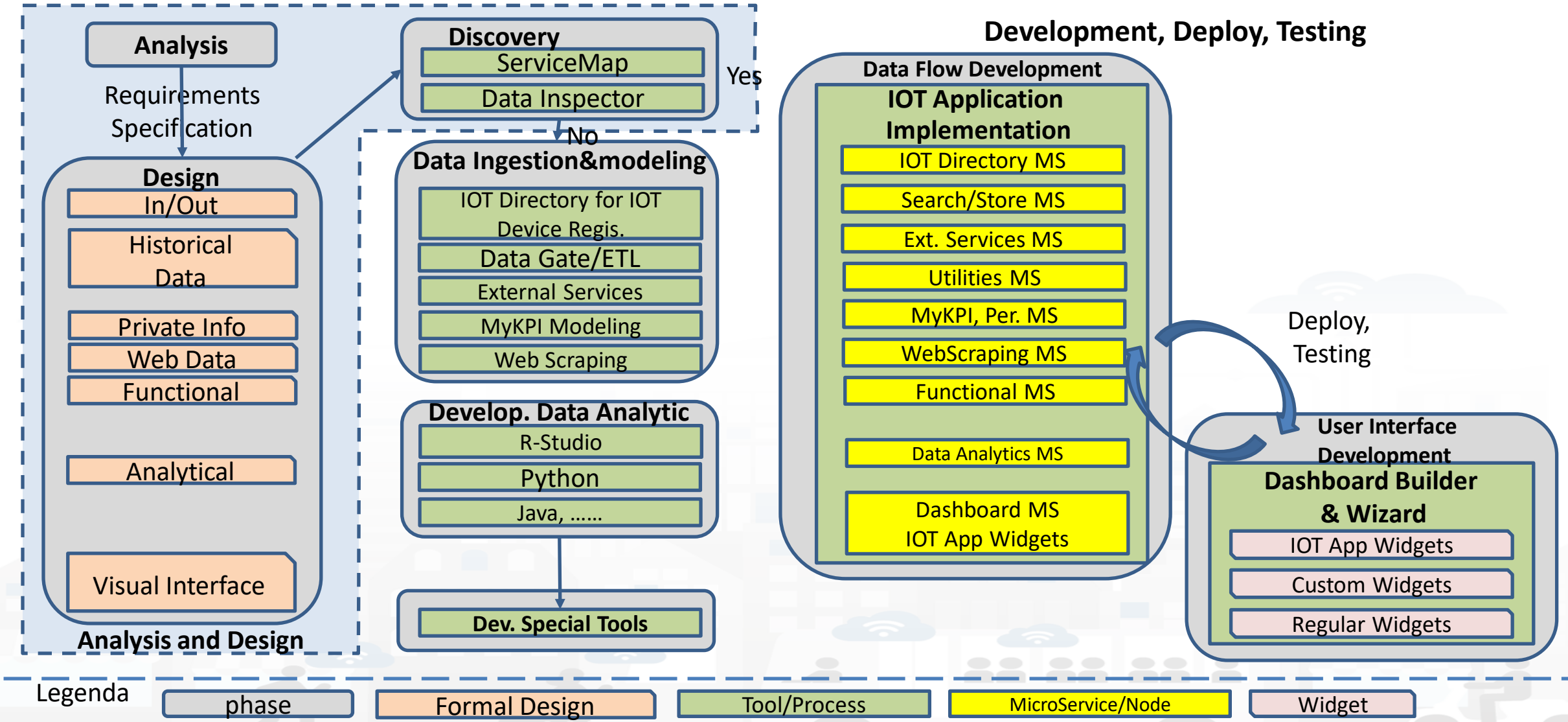
High level life cycle



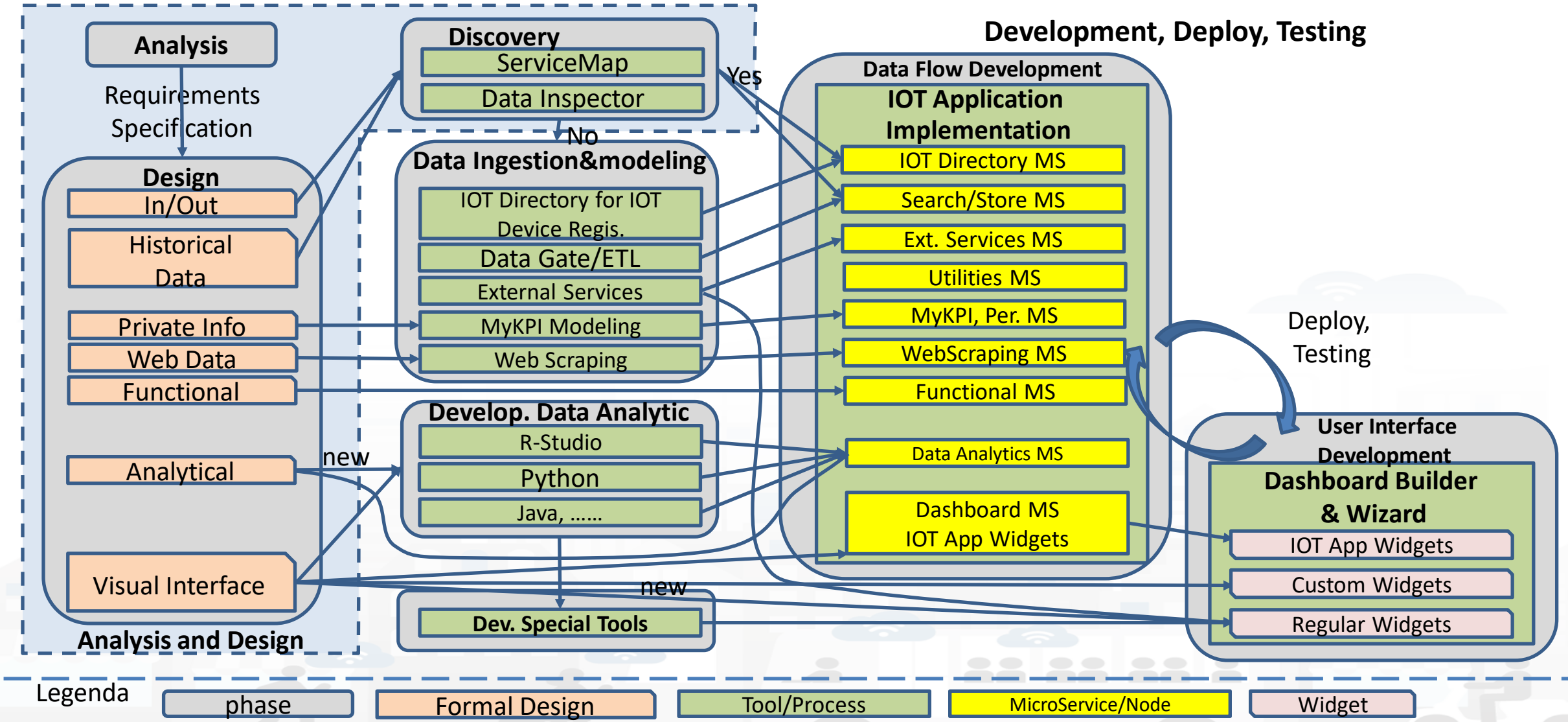
High level life cycle



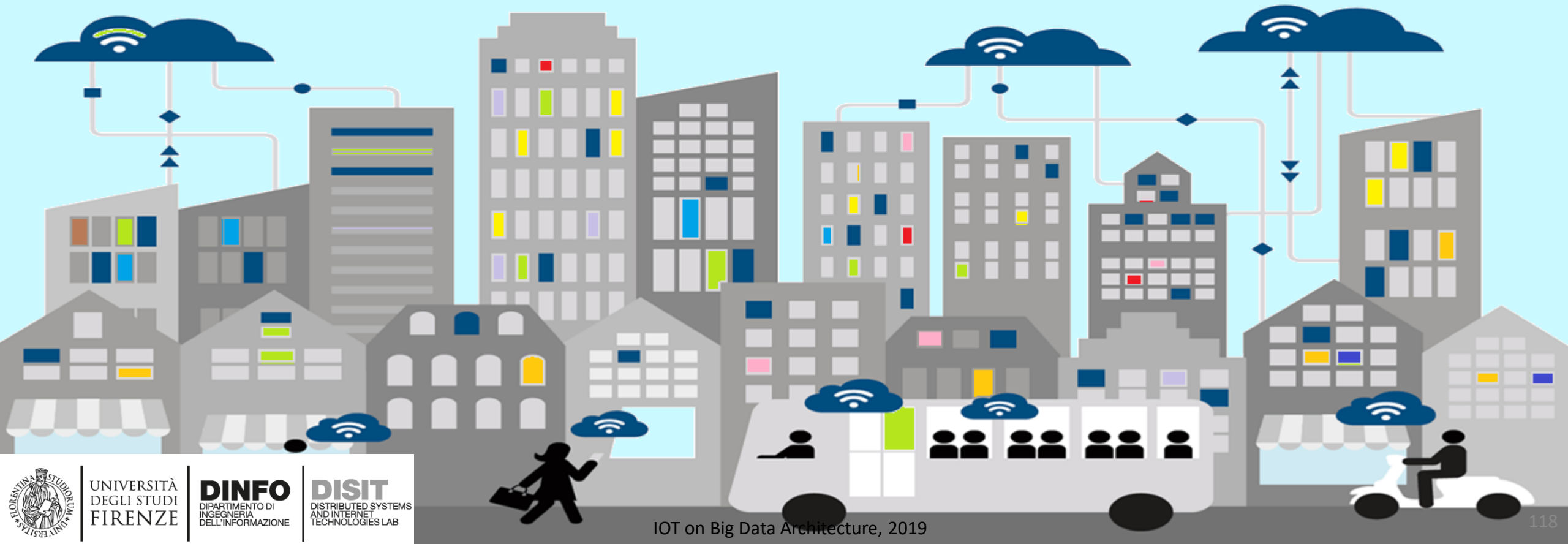
Detailed Life Cycle



Detailed Life Cycle



From Data to Applications and Dashboards



Sentient City Control Room

REPLICATE

FIRENZE

Tue 16 Oct 16:18:39

INDICI DI CRITICITA' DELLA QUALITA' DELL'ARIA (ICQA): 2 — inviata comunicazione alla cittadinanza

OZONO: 200 µ/m³ — superata la soglia di informazione

39492 Utenti WiFi

STATI DI ALLERTA 9m

GENERAL | METEO

MINIMO | BASSO | MEDIO | ALTO

RISCHIO IDRAULICO

RISCHIO TEMPORALI

RISCHIO IDROGEOLOGICO

RISCHIO NEVE

RISCHIO GHIACCIO

Mar 16 Ott
Firenze
Nuvoloso
19°C / 24 °C
Powered by LaMMA

Mer 17 Ott 16°C / 24°C	Nuvoloso
Gio 18 Ott 15°C / 26°C	Nuvoloso
Ven 19 Ott Temp N/A	Sereno
Sab 20 Ott Temp N/A	Sereno

TPL

N	14	57	21
Attesa	3'	8'	5'
Ritardo	2'	0'	2'

COLONNINE RICARICA 9m

180 INSTALLATE

81.1 % ATTIVE

8.9 % IN USO

REPLICATE

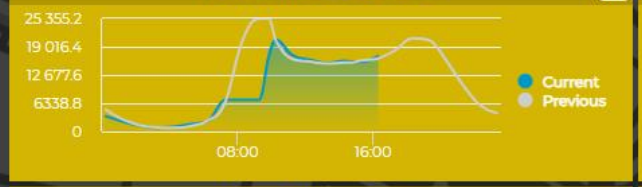
DISIT

FLORENCE DASHBOARD

This dashboard is the main entry point to access dashbaords realised in the REPLICATE H2020 EC project.

REPLICATE has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 691735.

FLUSSI INGRESSO CITTA 9m

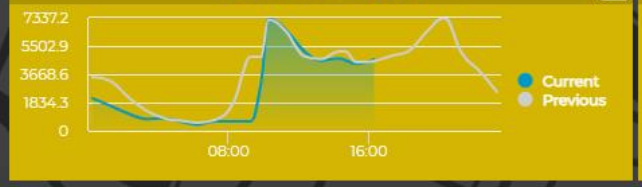


TOTALE 9m

141608

VEICOLI

FLUSSI INGRESSO ZTL 9m



TOTALE ZTL 9m

41146

VEICOLI

SITUAZIONE VIABILITA 54s

4 INCIDENTI

0 CHIUSURE AL TRAFFICO (TOT)

0 CHIUSURE PER CANTIERI

0 PROGR. | 0 NON PROG.

0 LIMITAZIONI AL TRAFFICO (TOT)

0 LIMITAZIONI PER CANTIERI

0 NON PROG. | 0 PROGR.

4 TOT. EVENTI SULLA RETE

SMN 9m	BINARIO16 9m	FORTEZZA 9m
63.4 % occupati su 901 posti	83 % occupati su 165 posti	17.9 % occupati su 521 posti
LEOPOLDA 9m	**CALZA 9m**	**S.AMBROGIO 9m**
36.3 % occupati su 300 posti	69.3 % occupati su 218	67 % occupati su 379 posti
PARTERRE 9m	**CAREGGI 9m**	**BECCARIA 9m**
64.9 % occupati su 106 posti	90.4 % occupati su 406 posti	78.6 % occupati su 210 posti

STATO TRIAGE CAREGGI 9m

Red code	Yellow code	Green code	Blue code	White code
3	12	83	37	9

MAPPA

Energy | Environment | Mobility | Social | Resilience

PM10	Riciclo rifiuto	Rifiuto per abitante	PIL residenti	Tasso di disoccupazione	Piste Ciclabili
26 superamenti/anno	56%	0,629 t/pers/anno	23.606 euro/pers	6,8%	19.7% km ciclabili/km totali

http://www.darionardella.it/il-sindaco-dario-nardella-in-missione-a-madrid-e-barcellona/

UNIVERSITÀ DEGLI STUDI FIRENZE

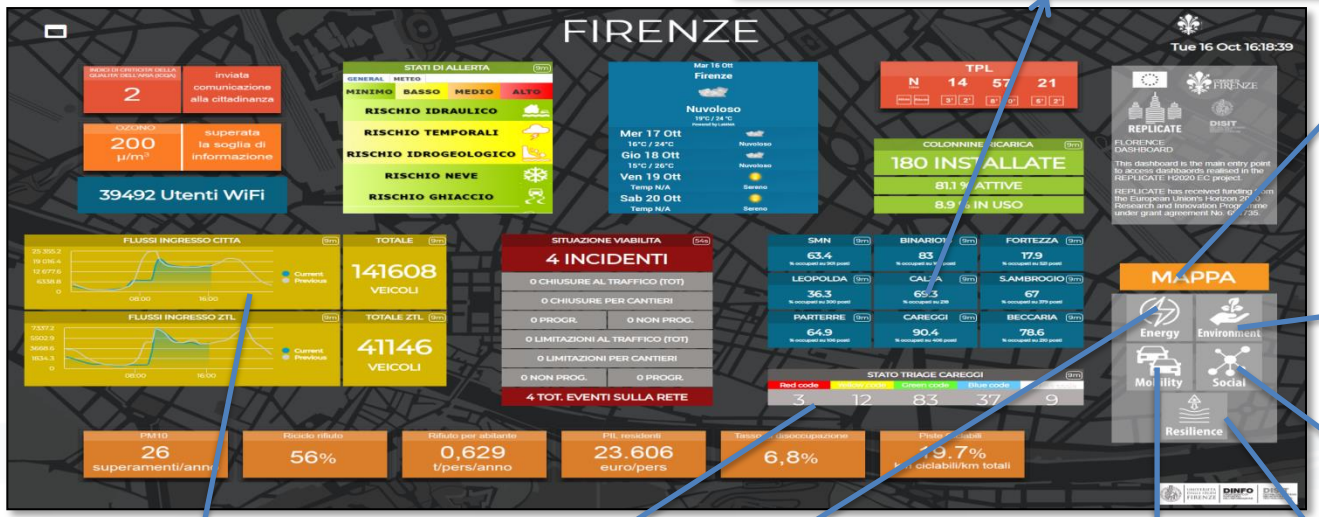
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

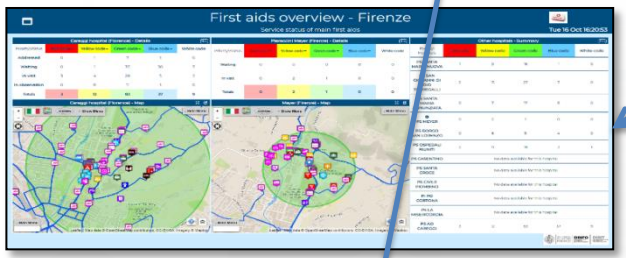
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

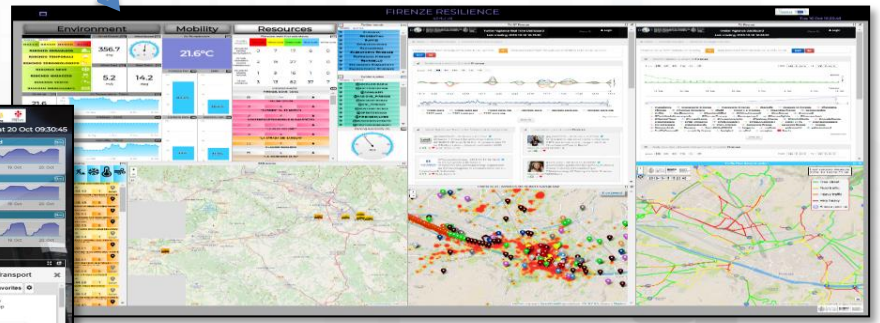
http://www.disit.org

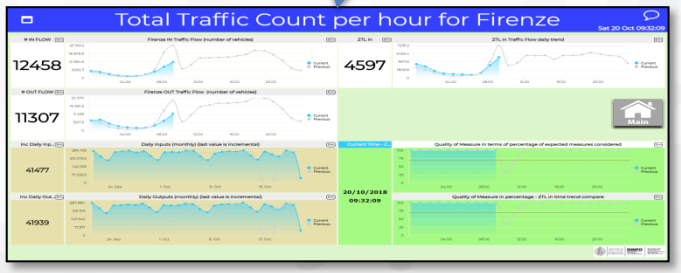
REPLICATE

KM4CITY









Firenze Oggi 2019

Fri 25 Oct 23:29:38

43666
Totale utenti WIFI

COLONNINE RICARICA
176 INSTALLATE
71 % ATTIVE
5.1 % IN USO

GENERAL | METEO

MINIMO	BASSO	MEDIO	ALTO

RISCHIO IDRAULICO
RISCHIO TEMPORALI
RISCHIO IDROGEOLOGICO
RISCHIO NEVE
RISCHIO GHIACCIO
RISCHIO VENTO

SITUAZIONE VIABILITA
0 INCIDENTI
0 CHIUSURE AL TRAFFICO (TOT)
0 CHIUSURE PER CANTIERI
0 PROGR. | 0 NON PROG.
0 LIMITAZIONI AL TRAFFICO (TOT)
0 LIMITAZIONI PER CANTIERI
0 NON PROG. | 0 PROGR.
0 TOT. EVENTI SULLA RETE

SMN	BINARIO16	FORTEZZA
28.7 % occupati su 607 posti	55.2 % occupati su 165 posti	27.8 % occupati su 521 posti
LEOPOLDA	**CALZA**	**S.AMBROGIO**
36 % occupati su 300 posti	70.3 % occupati su 148	99.7 % occupati su 379 posti
PARTERRE	**CAREGGI**	**BECCARIA**
34 % occupati su 656 posti	24.9 % occupati su 406 posti	98.1 % occupati su 210 posti

ANALYSIS
Energy | Environment | Mobility | Social | Resilience

FLUSSI INGRESSO CITTA
26 393.2 / 19 794.9 / 13 196.6 / 6598.3 / 0
12:00
Current / Previous

TOTALE
284094
VEICOLI

FLUSSI INGRESSO ZTL
5522 / 4141.5 / 2761 / 1380.5 / 0
12:00
Current / Previous

TOTALE ZTL
57499
VEICOLI

Nati Italiani	Nati stranieri	Deceduti	Matrimoni	Unioni Civili
163 ultimo mese consolidato	49 ultimo mese	395 ultimo mese	19 ultimi 7 giorni	0 ultimi 7 giorni

Segnalazioni ricevute in attesa	In Lavorazione	Risolte	Chiuse senza risoluzion...
1116 ultimo mese	524	305	285

Manutenzioni Stradali	Verde Pubbli...	Decoro Urbano	Relitti
54 oggi	4	6	3

Attesa media alla fermata

Linea 6	Linea 13
3 min	13 min
Linea 17	**Linea 23**
4 min	5 min
Linea 31	**Linea 36**
19 min	2 min

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTQzOA==

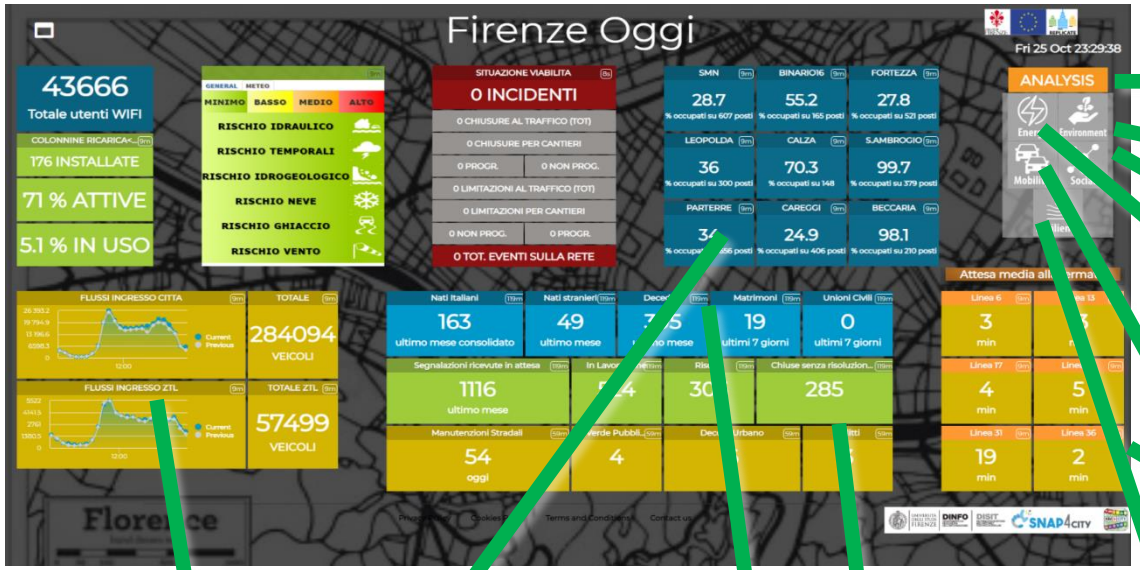
Smart City Control Room

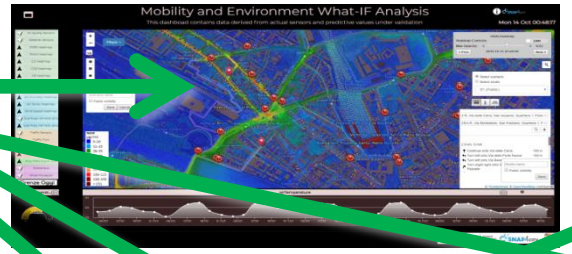
a set of dashboards and tools

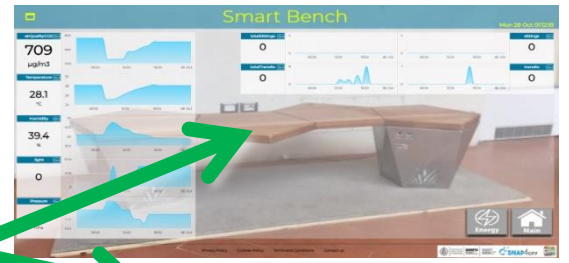
REPLICATE

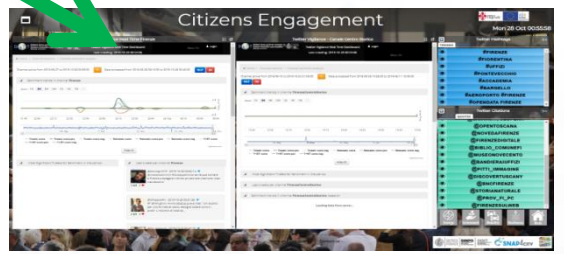
This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 691735

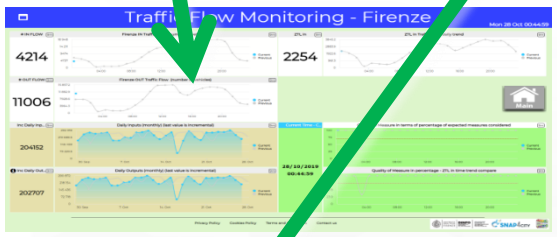
FIRENZE CITTÀ FARO

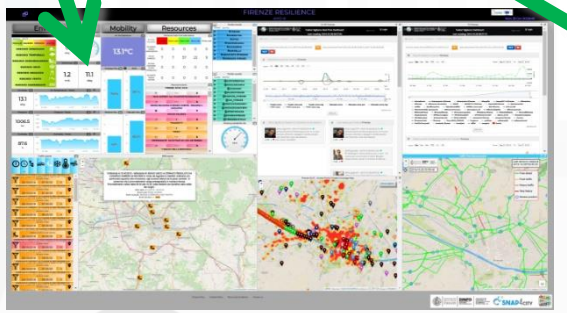


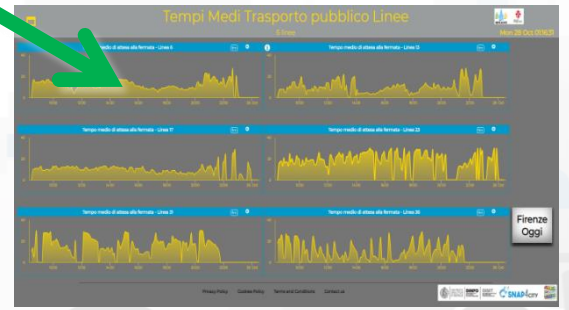












Data Protection, Personal Data vs GDPR

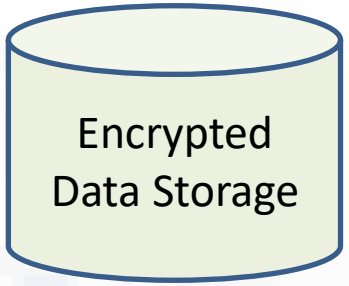
GDPR: General Data Protection Regulation

- **Users are** going to decide to:
  - provide access to who, for do what, until we consent
  - accept terms of use by **signed** consent **for each** data management **service**, *before was a simple informed consent*
- **from each service, the user has** to be capable to
  - **See** what the provider collect in terms of its Data Type: traces, logs, paths, profiles, accesses, IOT devices, sensors, maps, etc.
  - **Download**, **delete**, **inspect** each single Data Type
  - **Auditing** and **Revoke access** or **grant** access right to **each single Data Type**
  - **Delete all Data Types in single shot** or singularly (**forget all about me**)

- Correctness
- Transparency
- Security
- Integrity
- Privacy
- Auditing
- ….

GDPR: General Data Protection Regulation

- If personal data are **published by the owner**
  - the data have to be **released anonymously**,
    → also in this case they can be **revoked at any time**:
  - **Complexity reside** on: *distributed vs centralized control, revoke of Votes/scores, comments, …. If they are saved singularly or they already exploited in processing*
- GDPR also imposes **Technical Constraints** such as:
  - **Secure connection** in any private data exchange
  - **Encrypted** data store for all private data
  - **Decoupling** data and personal IDs
  - Allow the **Auditing** of private data usage
- **Relevant taxation** is foreseen when rules are violated, % of turnover



.....

WSs, HTTPS

WSs, HTTPS

WSs, HTTPS

IOT Devices

[IOT Edge]

IOT Broker

[IOT Application]

Dashboard Engine

WSs HTTPS

Sensors/ Actuators

Executing local computation

Shadow

Making IOT data more available

Data Analytics

MicroServices
Ext-Services
.....

Executing permanent computation

Internet

Smart City Knowledge Base and RT data

Parallel Computing

Ext Services

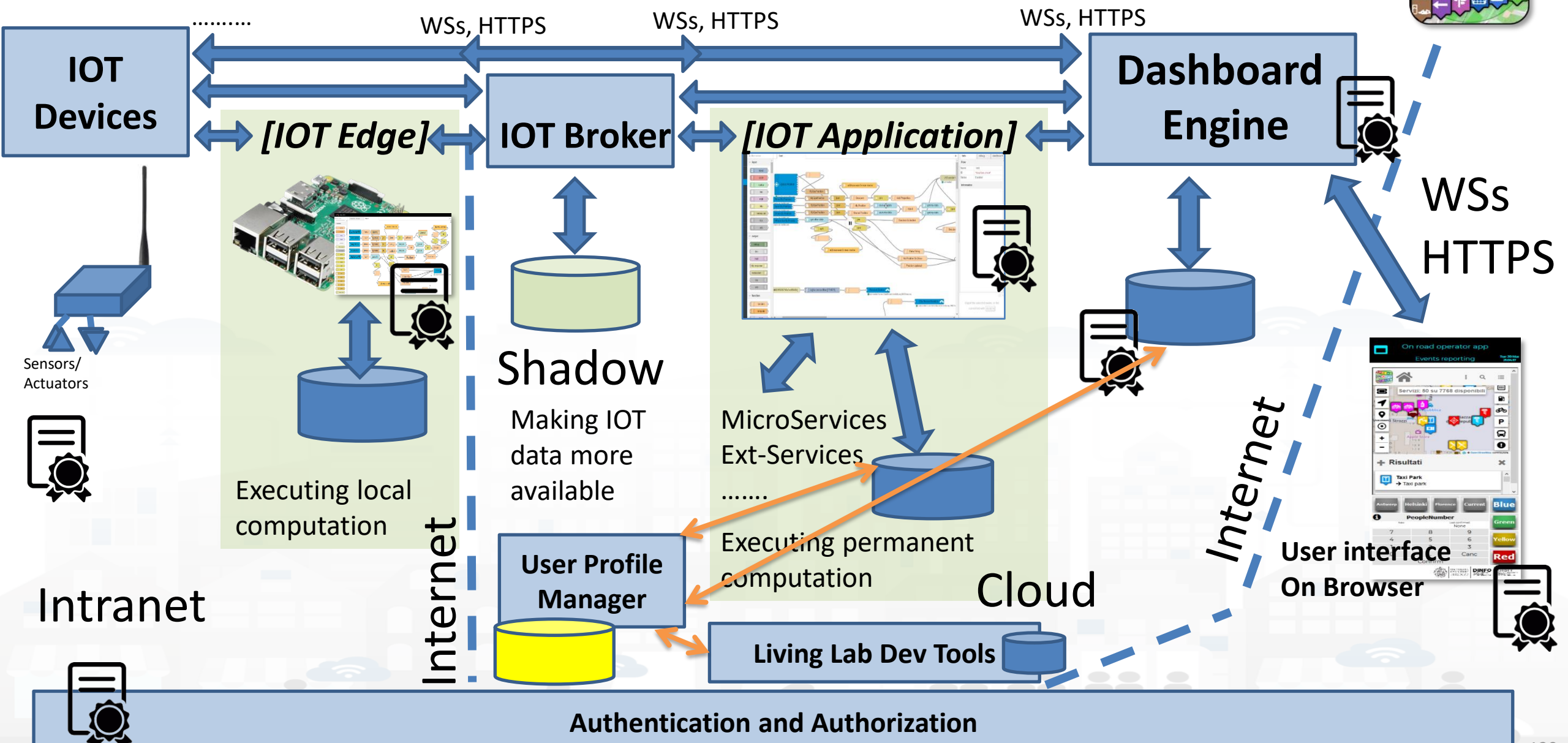
Cloud

Internet

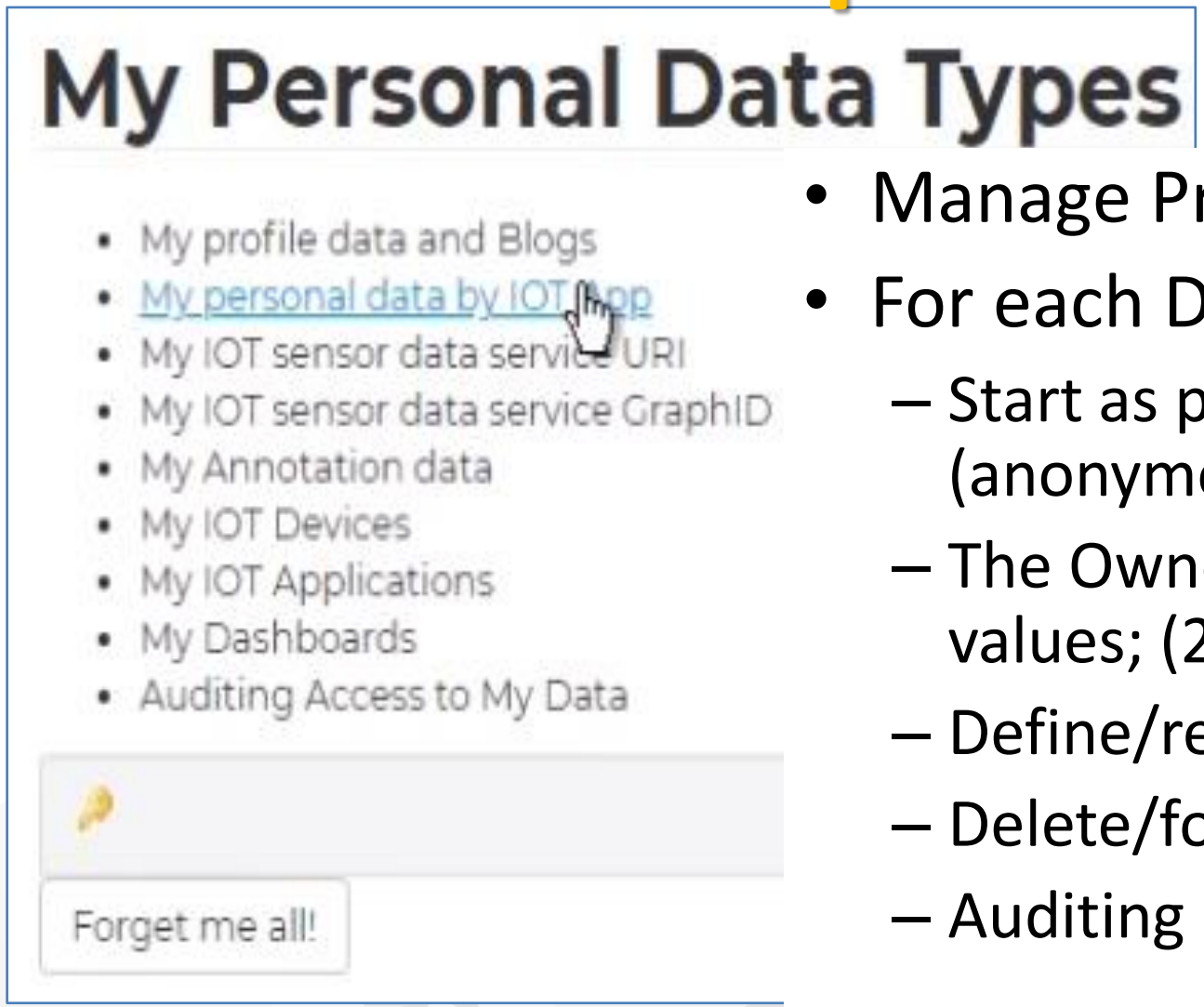
User interface On Browser

Intranet

KM 4 CITY


.....
WSs, HTTPS
WSs, HTTPS
WSs, HTTPS
IOT Devices
[IOT Edge]
IOT Broker
[IOT Application]
Dashboard Engine
WSs
HTTPS
Sensors/
Actuators
Executing local computation
Shadow
Making IOT data more available
MicroServices
Ext-Services
.....
Executing permanent computation
Internet
User Profile Manager
Cloud
Living Lab Dev Tools
Internet
User interface On Browser
Intranet
Authentication and Authorization

GDPR Compliant



- Manage Profile and MyPersonalData
- For each Data Type:
  - Start as private → making them public (anonymous) and revoke
  - The Owner is the only one that can: (1) modify values; (2) change the ownership
  - Define/revoke Delegation to Access
  - Delete/forget per Data Type and "me all!".
  - Auditing

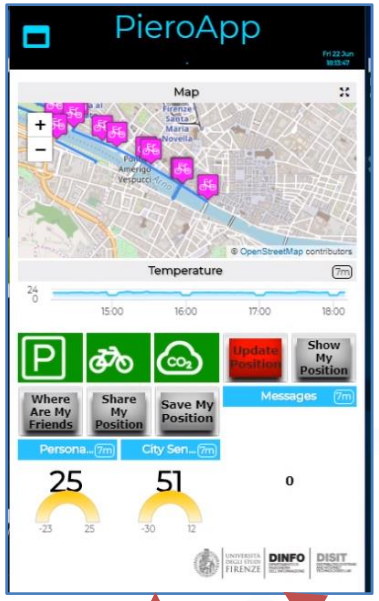
Managing MyPersonalData in secure manner

Examples:

- 1) Social IOT: A group of friends share some data with other according to GDPR: GPS position, Medical parameters as Glucose, etc.
- 2) saving and retrieve personal sensitive information.

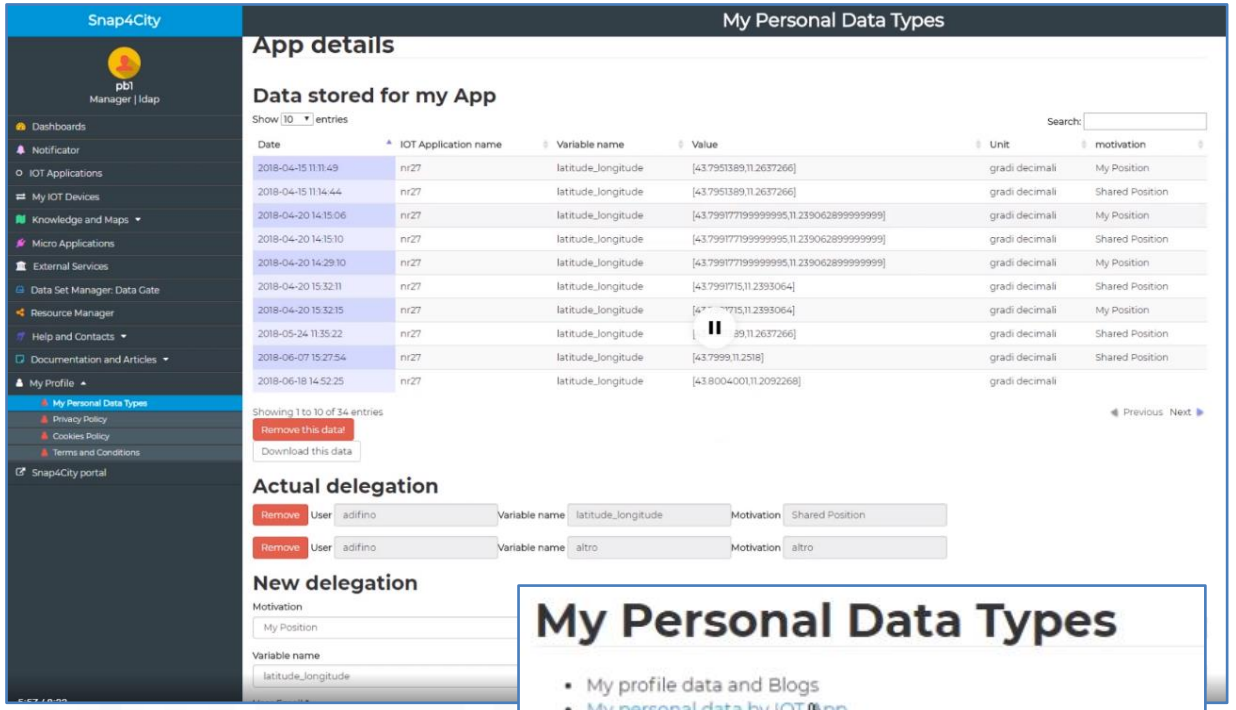
The users manage their Personal data via personal mobile Dash and IOT App, and configuration on the portal and/or Mobile App

Managing MyPersonalData in secure manner

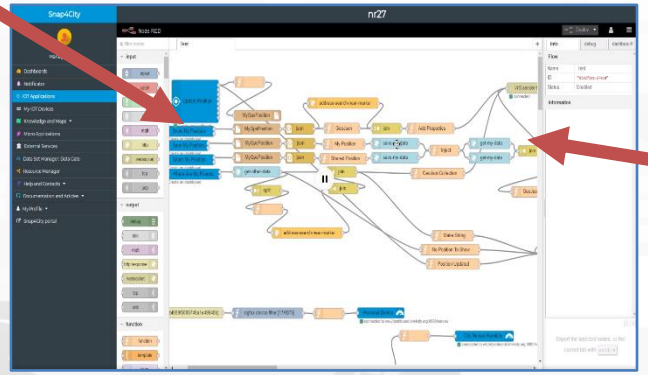


Example:

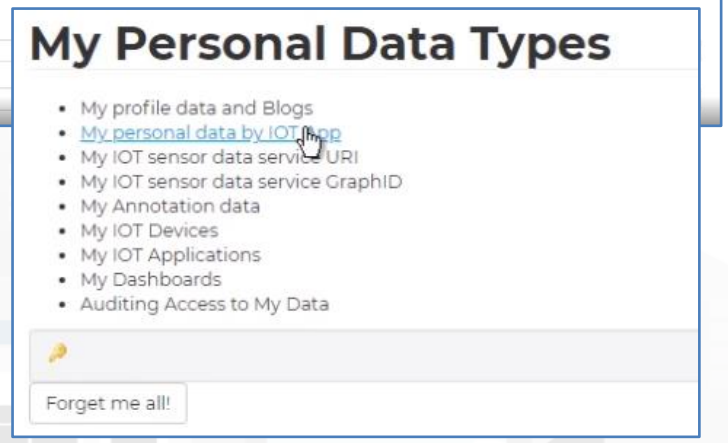
- Piero shares some data with selected friends according to GDPR: GPS position
- He managed the data via personal mobile Dashboard and IOT Application



Smart City Services and IOT/IOE



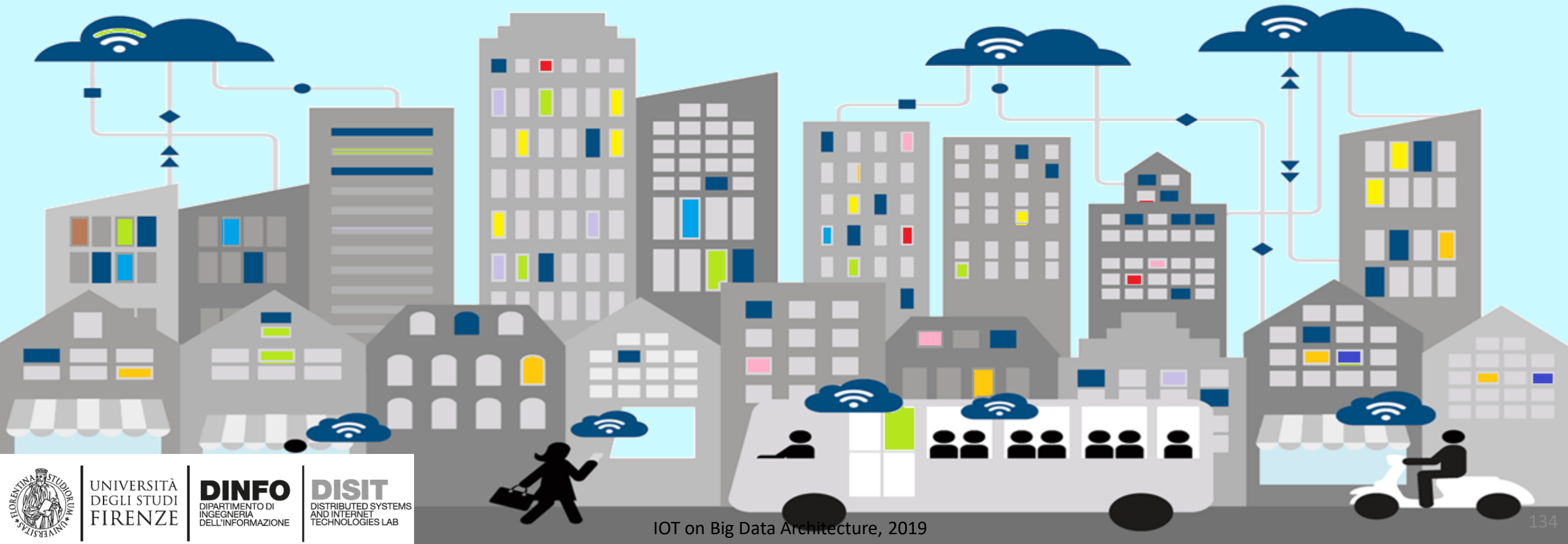
Encrypted Data Storage



Some Consideration on GDPR

- **Complexity of GDPR with end-to-end secure connections**
  - IOT Platforms as AWS, Microsoft Azure, Google IOT, etc. are not compliant yet.
  - Smart city GIS platforms as ESRI ArcGIS are not compliant yet.
  - Many Smart City platforms are not compliant yet.
- **Limitations are usually applied to simplify the solutions**
  - Limiting the number of supported protocols
  - Selling proprietary devices that may be attached on that secure chain
- **Snap4City is resulting platform developed for Helsinki and Antwerp to satisfy the above described requirements in** Open Source

Further Reading



Articles

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- V. Grasso, A. Crisci, M. Morabito, P. Nesi, G. Pantaleo, "Public crowdsensing of heat waves by social media data", Adv. Sci. Res., 14, 217-226, https://doi.org/10.5194/asr-14-217-2017, 2017, 10.5194/asr-14-217-2017 . http://www.adv-sci-res.net/14/217/2017/

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Articles

SNAP4CITY

KM4CITY

- A. Crisci, V. Grasso, P. Nesi, G. Pantaleo, I. Paoli, I. Zaza, "Predicting TV programme Audience by Using Twitter Based Metrics", Multimedia Tools and Applications, springer. 10.1007/s11042-017-4880-x, 2017 https://link.springer.com/article/10.1007/s11042-017-4880-x
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- Https://www.snap4city.org
  - It contains about 30 articles, 20 video and 150 Tutorials about the platforms
- Https://www.km4city.org
  - If contains about video and a number of technical manuals

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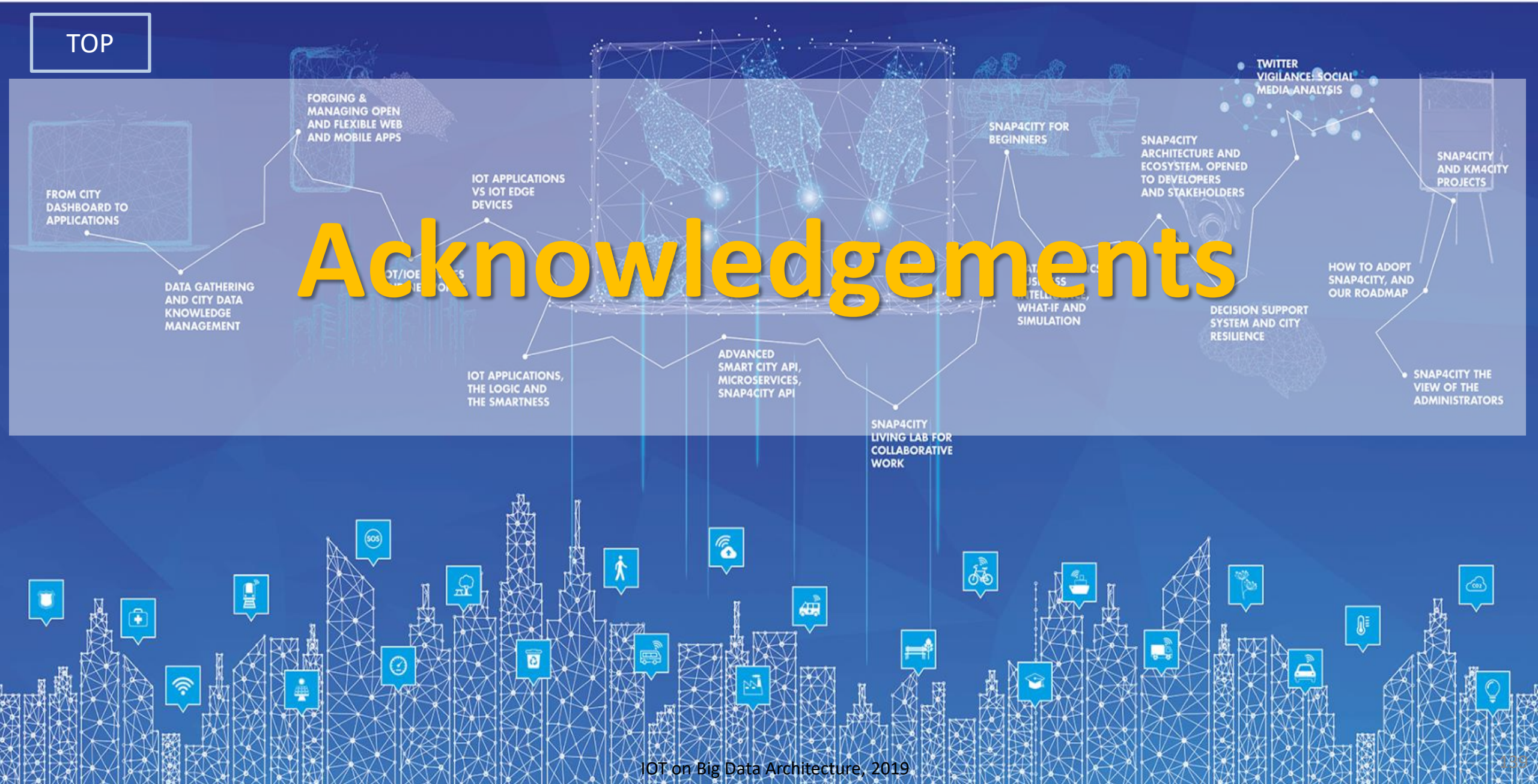
Acknowledgements



Acknowledgements

- Thanks to the European Commission for founding. All slides reporting logo of **Snap4City** https://www.snap4city.org **of Select4Cities H2020** are representing tools and research founded by European Commission for the **Select4Cities** project. **Select4Cities** has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation Programme (grant agreement n° 688196)
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- Thanks to the European Commission for founding. All slides reporting logo of **RESOLUTE H2020** are representing tools and research founded by European Commission for the RESOLUTE project. **RESOLUTE** has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation Programme (grant agreement n° 653460).
- Thanks to the MIUR for co-founding and to the University of Florence and companies involved. All slides reporting logo of **Sii-Mobility** are representing tools and research founded by MIUR for the Sii-Mobility SCN MIUR project.
- **Km4City** *is an open technology and research line of DISIT Lab exploited by a number of projects. Some of the innovative solutions and research issues developed into projects are also compliant and contributing to the Km4City approach and thus are released as open sources and are interoperable, scalable, modular, standard compliant, etc.*

DISIT lab roadmap vs model and tools' usage

2013 Km4City Ontology 1.1

- Tuscany Road Graph
- Mobility
- culture, tourism
- Events
- Parking
- Services
- Linked open graph

2014

- Weather Forecast
- Real Time Wi-Fi
- Entertainment
- Events
- LOD

ckan

- Twitter Vigilance
- Social Media Analytics, Sentiment Analysis

Km4City 1.4

2015

- Sardinia Region Smart City Strategies and plan

FIWARE

Km4City 1.5

(2015-18) resolute H2020

- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

E015 digital ecosystem Powered by EXPO MILANO 2015

2016

- Infomobility
- Mobile App
- Routing
- Multimodality

Sii-Mobility (2016-19) MIUR SII-MOBILITY SCN

Km4City 1.6.2

- Smart Energy
- Sustainable Mobility
- Control Room Dashboard

(2016-21) H2020 REPLICATE

Km4City 1.6.4

Sii-Mobility

- Origin-Destination and trajectories
- Traffic Reconstruction
- Offer Analysis
- OBU, smart devices

(2016-19) MIUR GHOST SIR

GREEN IMPACT C.A.P.A.C.I.T.Y.

Km4City 1.6.6 IOT/IOE

Node-RED

SNAP4CITY

SELECT for Cities H2020 (2017-19)

- IOT/IOE, IOT App
- Living Lab
- Maker Support
- IOT Edge
- Smart City IOT
- GDPR
- Privacy & Security

life weee (2017-20)

- Smart Waste

2017

TRAFAIR CEF (2018-21)

GREEN IMPACT POR FESR 2014-2020

- Industry 4.0
- Critical Plant
- Monitoring

Sii-Mobility

- User engagement
- Bike Sharing
- Data Analytics ++
- Social Predictions
- OBD2

2018

MOSAiC Mobility 4.0 for SmArt (i) City (2018-20)

- Mobility Demand / Offer Analytics and Strategy

(2018-21) 5G

5G tech
Energy
Industry 4.0
Synoptics

- Traffic and Mobility Impact on Pollution
- NOX predictions

2019

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