Architetture Parallele (Class. Flynn)

- **SISD**: Single instruction stream, single data stream
  - E.g.: un computer monoprocessore, monocore
- **SIMD**: Single instruction stream, multiple data stream
  - E.g.: le stesse istruzioni su tutti I nodi computazionali allo stesso tempo, ma lavorando su dati diversi, per esempio GPU su immagini
- **MISD**: Multiple instruction stream, single data stream
  - E.g.: ogni nodo puo' eseguire processi indipendenti ma sullo stesso stream di dati, un risultato singolo (poco realistico)
- **MIMD**: Multiple instruction stream, multiple data stream
  - E.g.: ogni nodo puo' eseguire processi indipendenti su dati diversi
  - Tipicamente la soluzione piu' utilizzata per il sistemi general purpose, cloud, etc.

Classificazione

- **SISD**: Single instruction stream, single data stream
  - Von Neumann
- **SIMD**: Single instruction stream, multiple data stream
  - Vector processor, Array processor
- **MISD**: Multiple instruction stream, single data stream
  - poco realistico

MIMD: Multiple instruction stream, multiple data stream

- **MultiProcessore**
  - Parallelismo interno al calcolatore
  - Memoria condivisa, variabili condivise
  - Sincronizzazioni
  - E.g., Uniform Memory Access: XEON
- **MultiComputer**
  - Cloud, architetture parallele
  - Comunicazione tramite canali dedicati,
  - Message passing, Send e Receive
    - Hypercubes
- **Sistemi Distribuiti**,
  - Cluster, Massive parallel processor
    - GRID, cloud, ..

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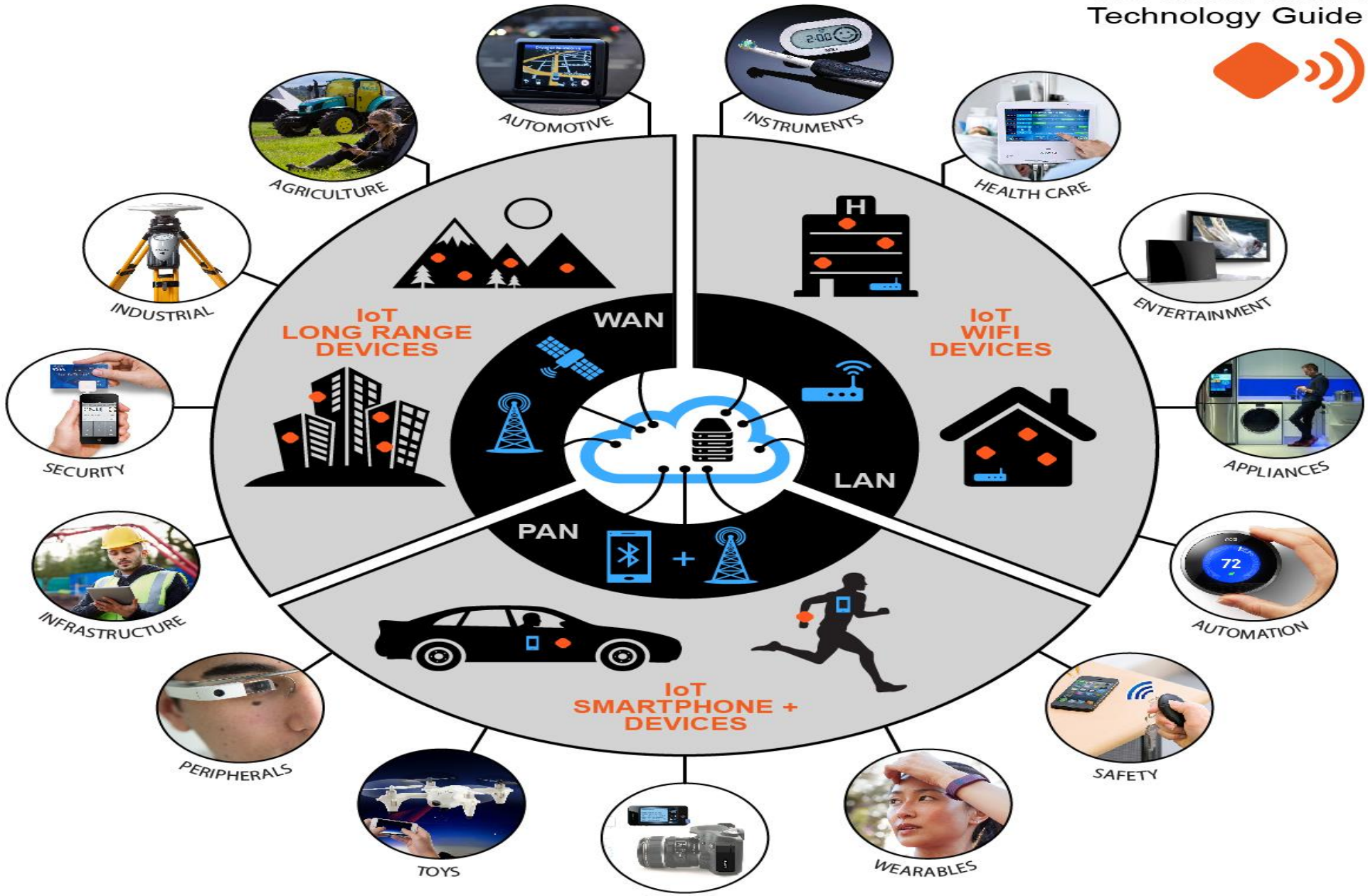
Data Lake vs Data Warehouse

https://www.snap4City.org https://www.Km4City.org

Parte: 3 (2024)


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

Architettura di base Big Data, IOT, Industry 4.0

Data Sources

Transatio ns sys, sensors Social media, ws, etc.

Data Stream analysis

Spark, Storm, Kafka

Big Data Cluster

HDFS, noSQL

Indexing

SOLR, Elastic search

Search and Query

Facet, cluster

Rendering acting

User interface, Dashboard Drill down

Data Transformation

ETL, NIFI

Data Analytics

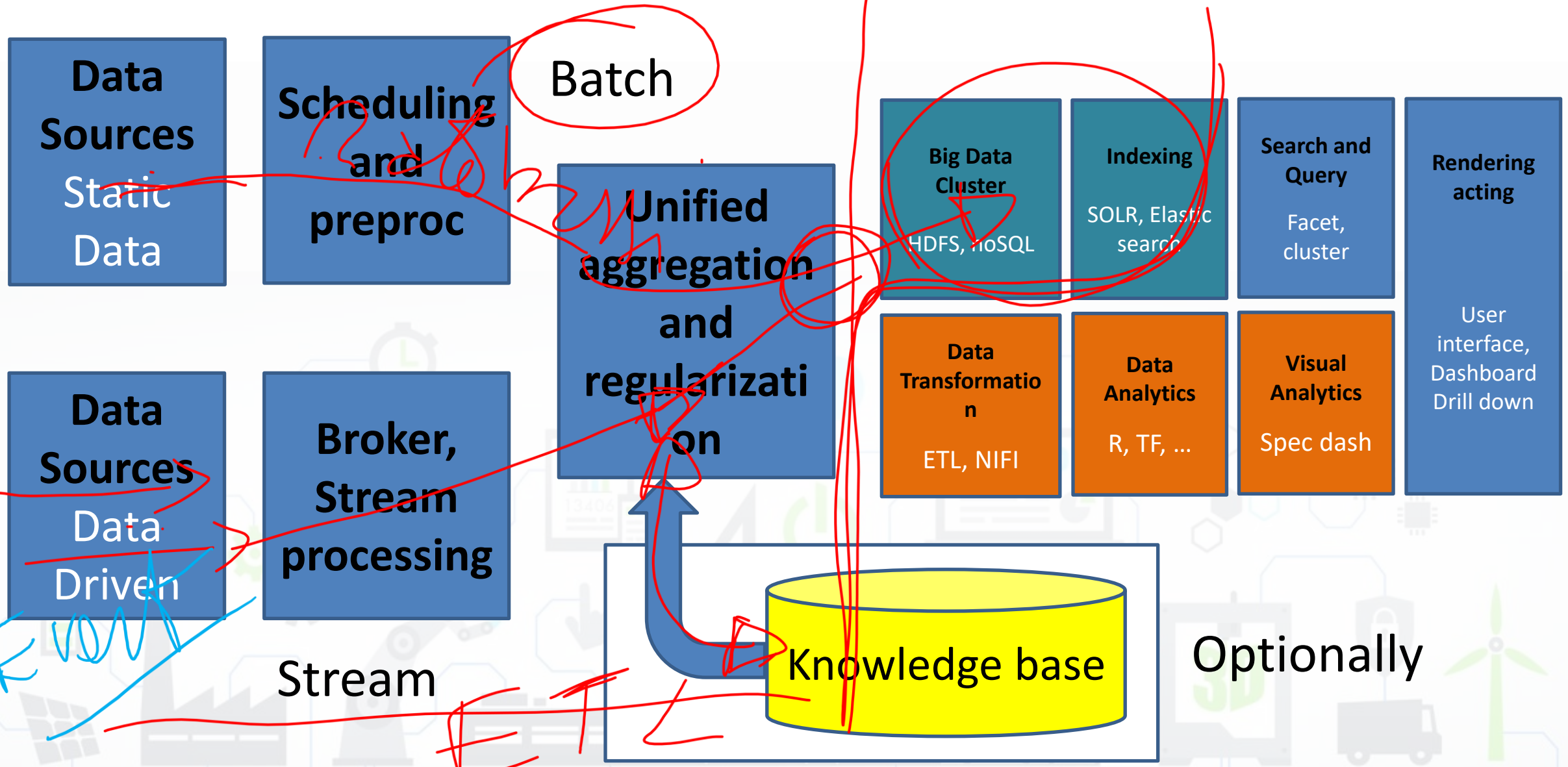
R, TF, …

Visual Analytics

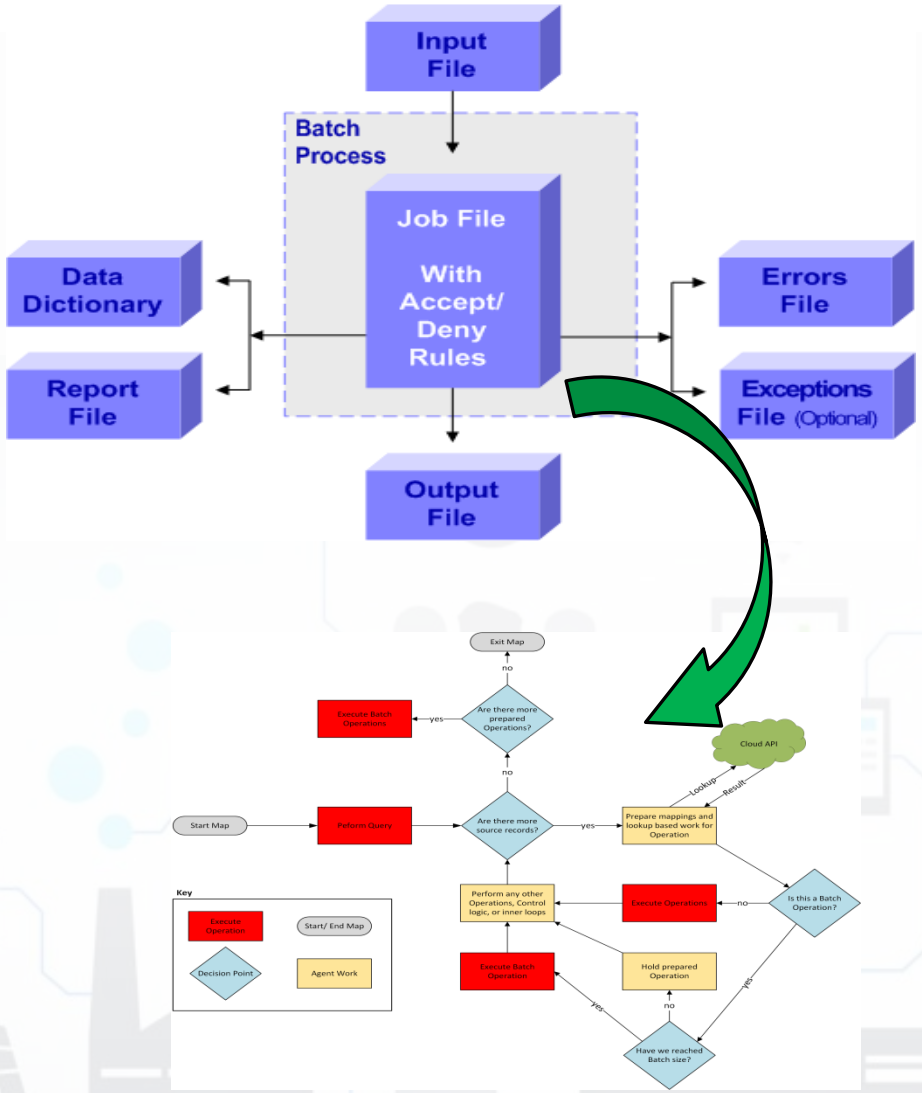
Spec Dash

Data Management: security, privacy, licensing, etc.

Lambda Architecture

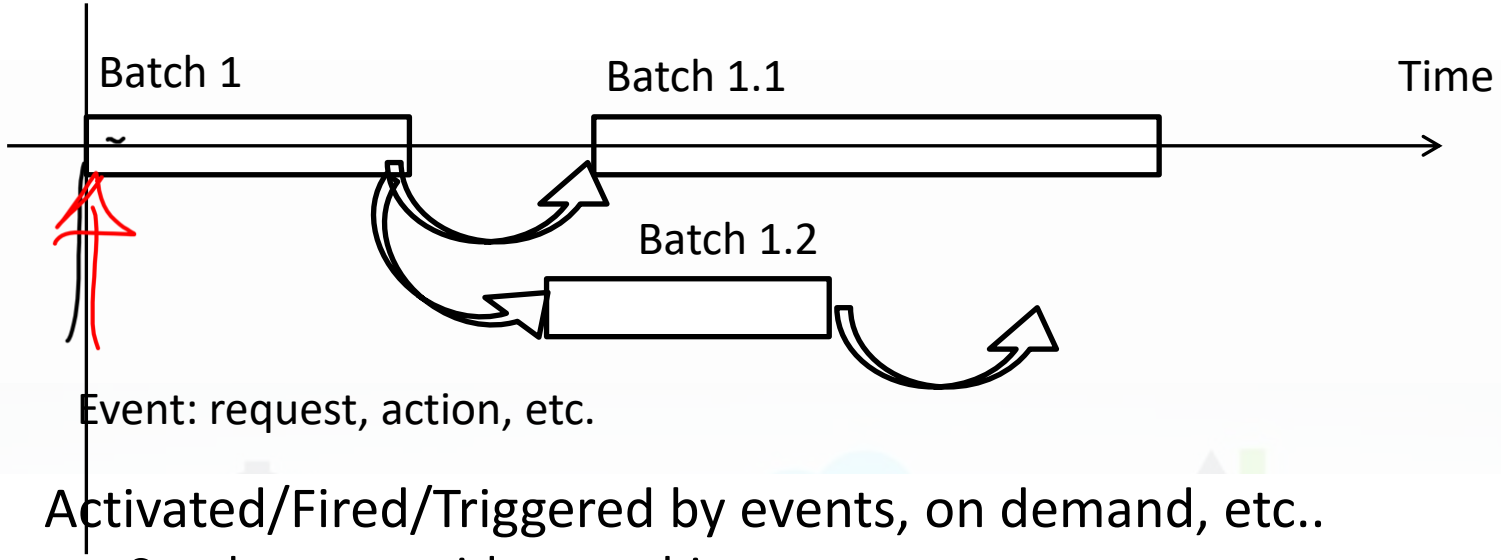


Batch Processing



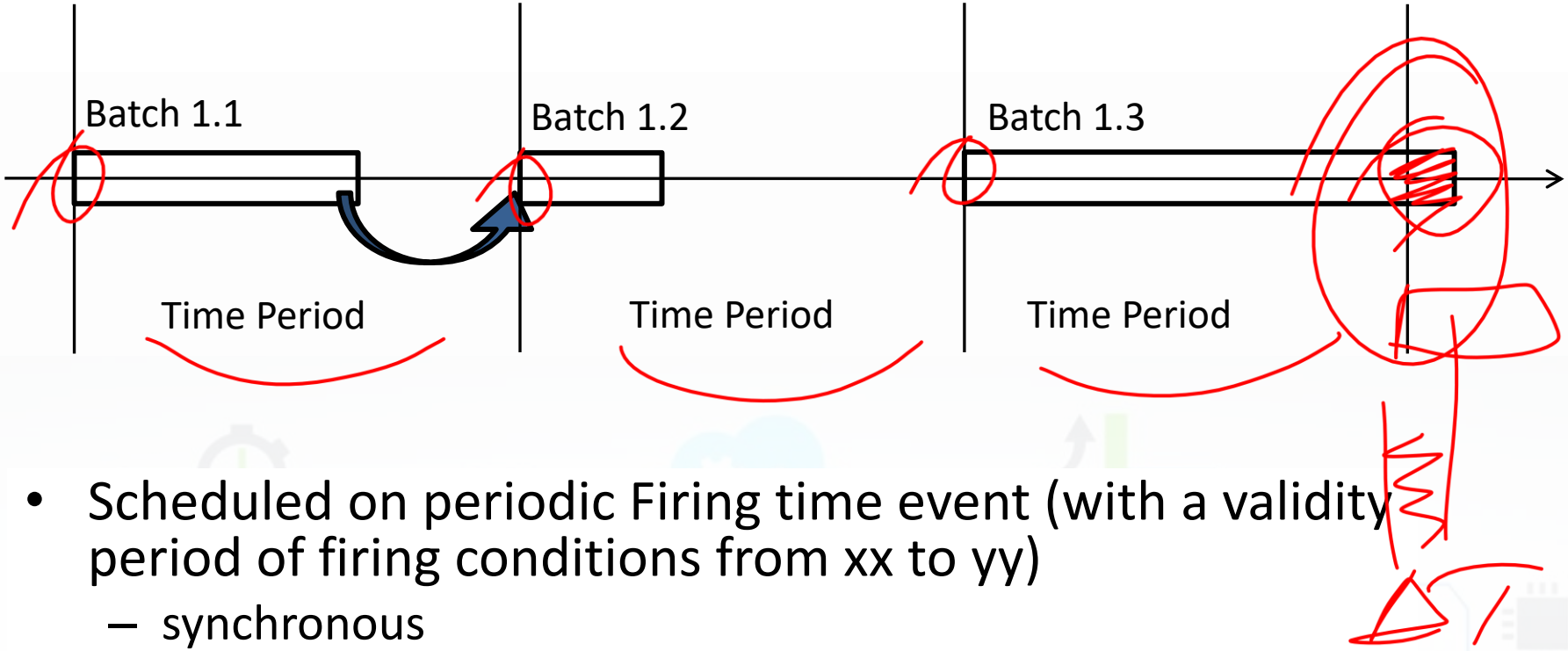
- Script language
- Smilar to workflow or flowchart
- Sequence of Commands
- Intermediate status on disk or memory
- Executed command driven:
  - On demand, sporadically
  - Periodically

aPeriodic Batch processing



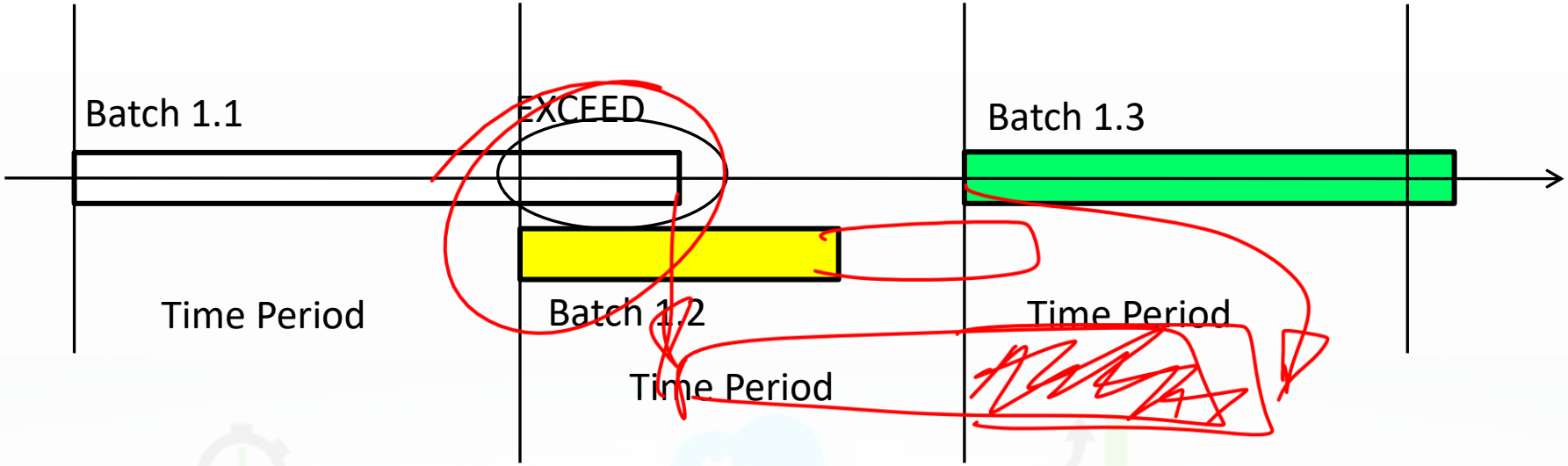
- Activated/Fired/Triggered by events, on demand, etc..
  - Synchronous with something
  - chained or not
- May fire/generate (ask to do or directly do) other jobs/batches:
  - on the same or different computers
  - Identical or different
- Activation may be asked to a third party manager
- Duration of execution depending on data !

Periodic Batch processing



- Scheduled on periodic Firing time event (with a validity period of firing conditions from xx to yy)
  - synchronous
- Execution time duration depending on data or other..
  - Execution may exceed the Time Period
- Each single execution MAY or MAY NOT depend on the preceding one

Periodic Batch processing



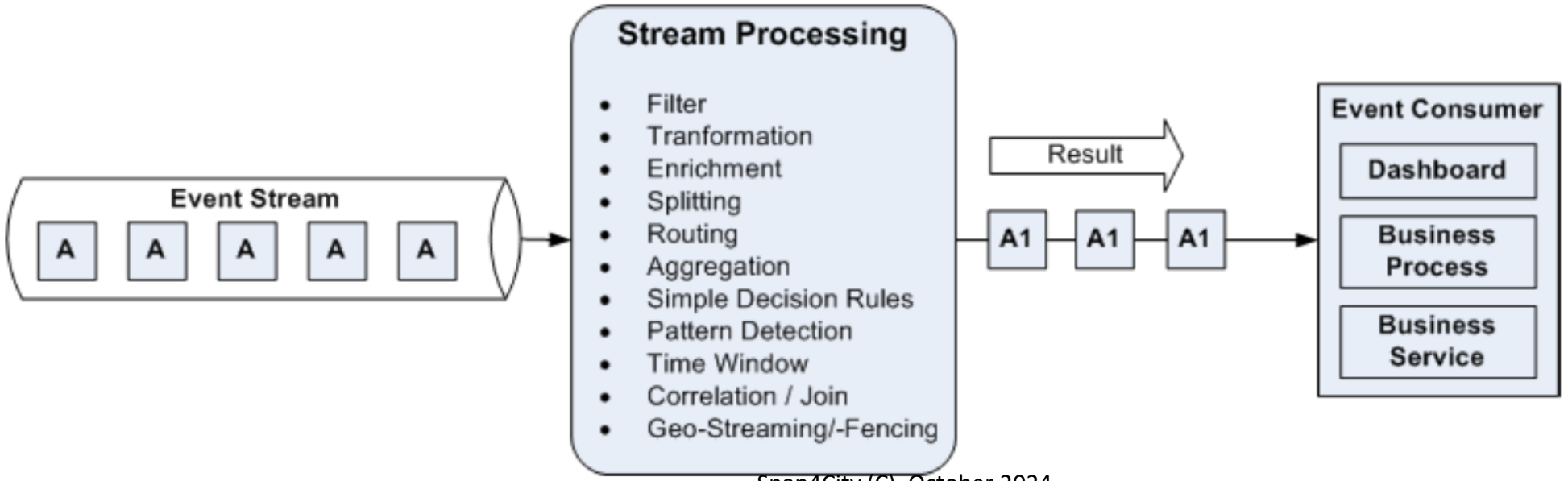
- If the Execution Time Duration exceeds the Time Period
  - A) the successive execution (Batch 1.2) is overlapped (yellow)
    - If it happens systematically: the number of tasks grow indefinitely consuming all resources → until crash
  - B) the successive execution (Batch 1.2) is canceled to wait for the next one (Batch 1.3, green),
    - skipping the second execution, Batch 1.2

Stream Processing

- paradigma di programmazione parallela
  - Detto anche di real time processing
- Lavora con:
  - Dati parziali e non su tutto l'insieme dei dati.
  - Per esempio: valutare il contenuto spettrale di un segnale:
    - Su tutto il segnale
    - Su una finestra temporale di 30 secondi, per ogni secondo un nuovo valore, small delay/latency, (but present , see pipeline)
- L'attivazione del processo corrisponde spesso all'arrivo del dato nello stream, nella pipeline,
  - si ha sincronizzazione e comunicazione in un solo colpo.
  - Tipicamente una sequenza di azioni semplici attivate da
    - l'arrivo delle condizioni e dei dati per calcolare i risultati
    - ed in modo asincrono
    - tipicamente senza avere necessità di memorizzare il dato
  - → elimina alcuni problemi della programmazione parallela.

Stream Processing

- Example on languages
  - SISAL (Streams and Iteration in a Single Assignment Language)
  - CUDA (Compute Unified Device Architecture) for NVIDIA GPU, SIMD
- Applications:
  - IOT, media recognition, log processing, social media enrichment, indexing,



Main Purpose

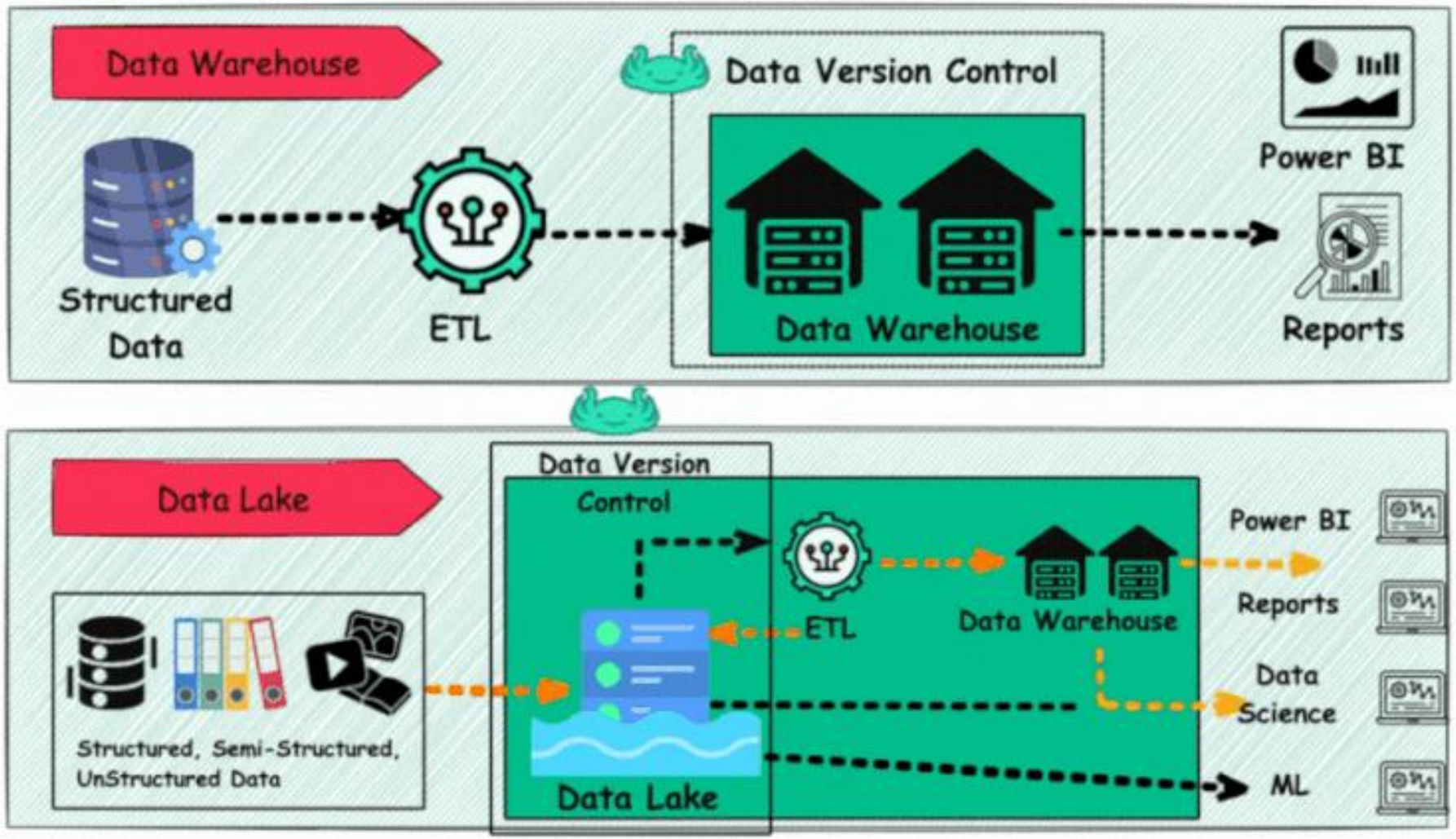
- To store a large amount of data, **big data**, and they can be **structured and un-structured**, several different kind of data:
  - **Direct Data**: Time series, geolocated data, events, shapes, measures, social media posts, video, files, logs, etc.
    - Most of them may have multiple features, e.g.: geolocated events with shape
  - **Derived Data**: predictions, typical trends, trajectories, flows, heatmaps, 3D reconstructions, traffic reconstruction, planning, simulations, etc.
- for **exploiting them** for producing:
  - Deductions, hints, early warning,
  - Derived Data as well, in real time

Main Functions

- **Data Extraction:**
  - gathering, harvesting, ingestion, reception in push, ….
- **Data Transformation:**
  - Adaptation, mapping, formatting, conversion, enrich
  - Cleaning or leaving as it is
- **Data Loading** and Refreshing: saving in the storage
  - As it is, converted and ready to use, etc.
- **Data Usage:**
  - As it is from Storage (faster, more rigid schema, higher volume in access)
  - Transformed on the fly (slower, more flexible, moderate volume in access)

DW vs DL

- ETL-Usage vs ELT-Usage
- DW:
  - More complex data ingestion
    - Simplify data ingestion for sporadically used data
  - Faster date usage unforeseen patterns/combinations
- DL:
  - Faster data ingestion
  - More complex data rendering since all combination are unplanned
    - Prepare data rendering for well known patterns


Data Warehouse
Data Version Control
Power BI
Structured Data
ETL
Data Warehouse
Reports
Data Lake
Data Version Control
ETL
Data Warehouse
Power BI
Reports
Data Science
ML
Structured, Semi-Structured, UnStructured Data
Data Lake

Parameters	Data Lake	Data Warehouse
Storage	In the data lake, all data is kept irrespective of the source and its structure. Data is kept in its raw form. It is only transformed when it is ready to be used.	A data warehouse will consist of data that is extracted from transactional systems or data which consists of quantitative metrics with their attributes. The data is cleaned and transformed
History	Big data technologies used in data lakes is relatively new.	Data warehouse concept, unlike big data, had been used for decades.
Data Capturing	Captures all kinds of data and structures, semi-structured and unstructured in their original form from source systems.	Captures structured information and organizes them in schemas as defined for data warehouse purposes
Data Timeline	can retain all data. This includes not only the data that is in use but also data that it might use in the future. Also, data is kept for all time, to go back in time and do an analysis.	In the data warehouse development process, significant time is spent on analyzing various data sources.
Users	ideal for the users who indulge in deep analysis. Such users include data scientists who need advanced analytical tools with capabilities such as predictive modeling and statistical analysis.	The data warehouse is ideal for operational users because of being well structured, easy to use and understand.
Storage Costs	Data storing in big data technologies are relatively inexpensive then storing data in a data warehouse.	Storing data in Data warehouse is costlier and time-consuming.

https://www.guru99.com/data-lake-vs-data-warehouse.html

Parameters	Data Lake	Data Warehouse
Task	can contain all data and data types; it empowers users to access data prior the process of transformed, cleansed and structured.	Data warehouses can provide insights into pre-defined questions for pre-defined data types.
Processing time	empower users to access data before it has been transformed, cleansed and structured. Thus, it allows users to get to their result more quickly compares to the traditional data warehouse.	Data warehouses offer insights into pre-defined questions for pre-defined data types. So, any changes to the data warehouse needed more time.
Position of Schema	Typically, the schema is defined after data is stored. This offers high agility and ease of data capture but requires work at the end of the process	Typically schema is defined before data is stored. Requires work at the start of the process, but offers performance, security, and integration.
Data processing	use of the ELT (**Extract Load Transform**) process.	Data warehouse uses a traditional ETL (**Extract Transform Load**) process.
Complain	Data is kept in its raw form. It is only transformed when it is ready to be used.	The chief complaint against data warehouses is the inability, or the problem faced when trying to make change in in them.
Key Benefits	They integrate different types of data to come up with entirely new questions as these users not likely to use data warehouses because they may need to go beyond its capabilities.	Most users in an organization are operational. These type of users only care about reports and key performance metrics.

https://www.guru99.com/data-lake-vs-data-warehouse.html

Pros and Cons

- **Data Lake**
  - Original data preserved, structured and unstructured
  - Lower costs of ingestion
  - Lower performance in the usage
  - Security: possible control at source
  - More difficult to extend in usage, simpler in storage
  - More scientist oriented
    - Moderated results in access

- **Data Warehouse**
  - Original data transformed and prepared for mainly structured or semi-structured
  - Higher cost of ingestion
  - Higher performance in the usage
  - Security: Control on organized data
  - More difficult to extend in storage, simpler in usage
  - More Business and Purpose Oriented
    - Large volume of accesses

DWH

Data Sources Static Data

Scheduling and preproc

Batch

Data Sources Data Driven

Broker, Stream processing

Stream

Unified aggregation and regularizati on

Storage

Big Data Cluster HDFS, noSQL	**Indexing** SOLR, Elastic search	**Search and Query** Facet, cluster	**Rendering acting** User interface, Dashboard Drill down
Data Transformati on ETL, NIFI	**Data Analytics** R, TF, …	**Visual Analytics** Spec dash	

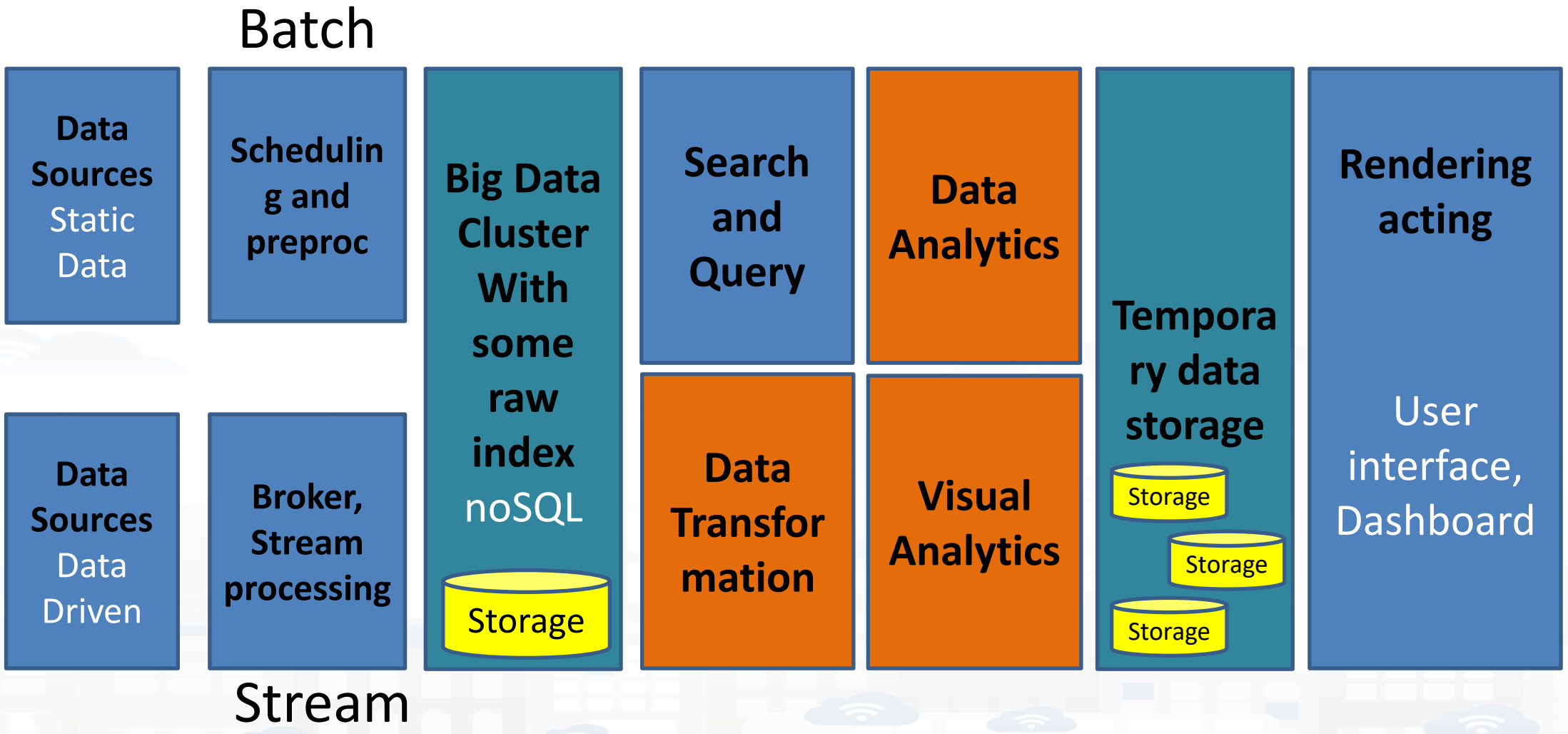
Knowledge base

Optionally

Top Cloud Data Warehouses at a Glance

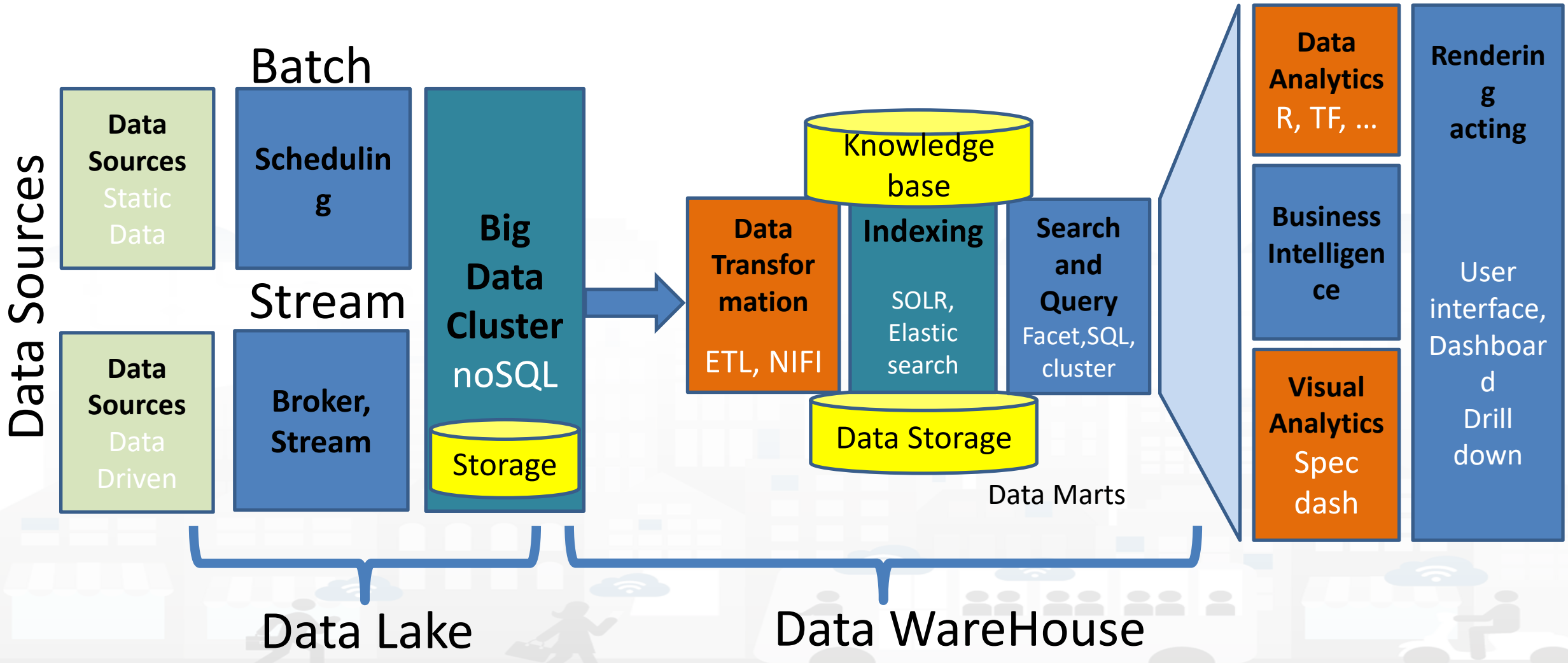
	Amazon Redshift	Microsoft Azure Synapse	Google BigQuery	Snowflake Cloud Data Platform
Initial Release	2012	2016	2010	2014
Separates Storage and Compute	No	Yes	Yes	Yes
Multi-Cloud	No	No	No	Yes
Query Language	Amazon Redshift SQL	TSQL	Standard SQL 2011 & BigQuery SQL	Snowflake SQL
Elasticity	Yes - Manual	Yes – Manual and Automatic	Yes – Automatic	Yes – Automatic
MPP	Yes	Yes	Yes	Yes
Columnar	Yes	Yes	Yes	Yes
Foreign Keys	Yes	Yes	No	Yes
Transaction	ACID	ACID	ACID	ACID
Concurrency	Yes	Yes	Yes	Yes
Durability	Yes	Yes	Yes	Yes
Automation	No	No	No	No
Website	Link	Link	Link	Link
Free Trial	Yes	Yes	Yes	Yes

DL


Batch
Data Sources Static Data
Scheduling and preproc
Big Data Cluster With some raw index noSQL
Storage
Search and Query
Data Analytics
Temporary data storage
Storage
Storage
Storage
Rendering acting
User interface, Dashboard
Data Sources Data Driven
Broker, Stream processing
Data Transformation
Visual Analytics
Stream

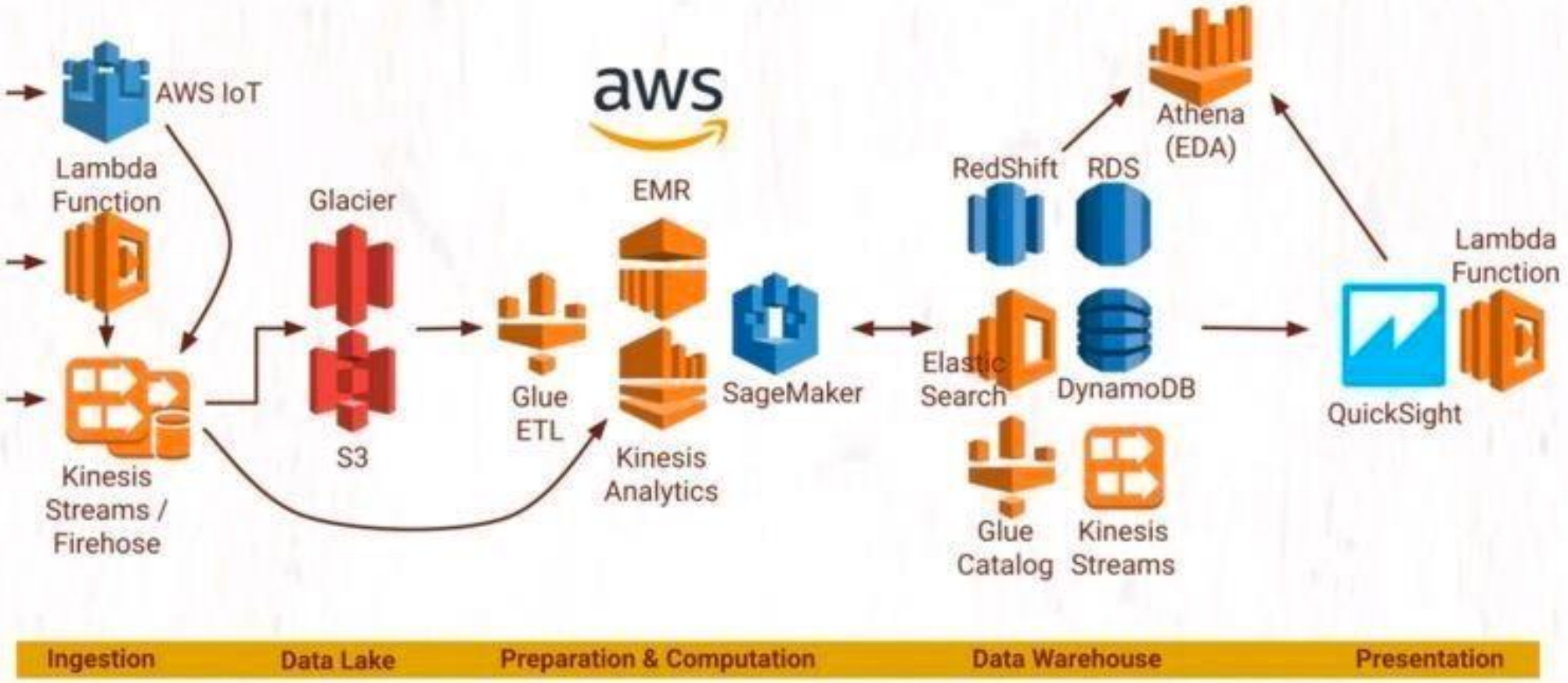
	Data Lake	Data Warehouse
Data Structure	Raw	Processed
Purpose of Data	Not yet determined	Currently in use
Users	Data scientists	Business professionals
Accessibility	Easier to ingest and update unstructured data	More difficult to ingest and update data due to the need for uniformity and structure, but easier to consume

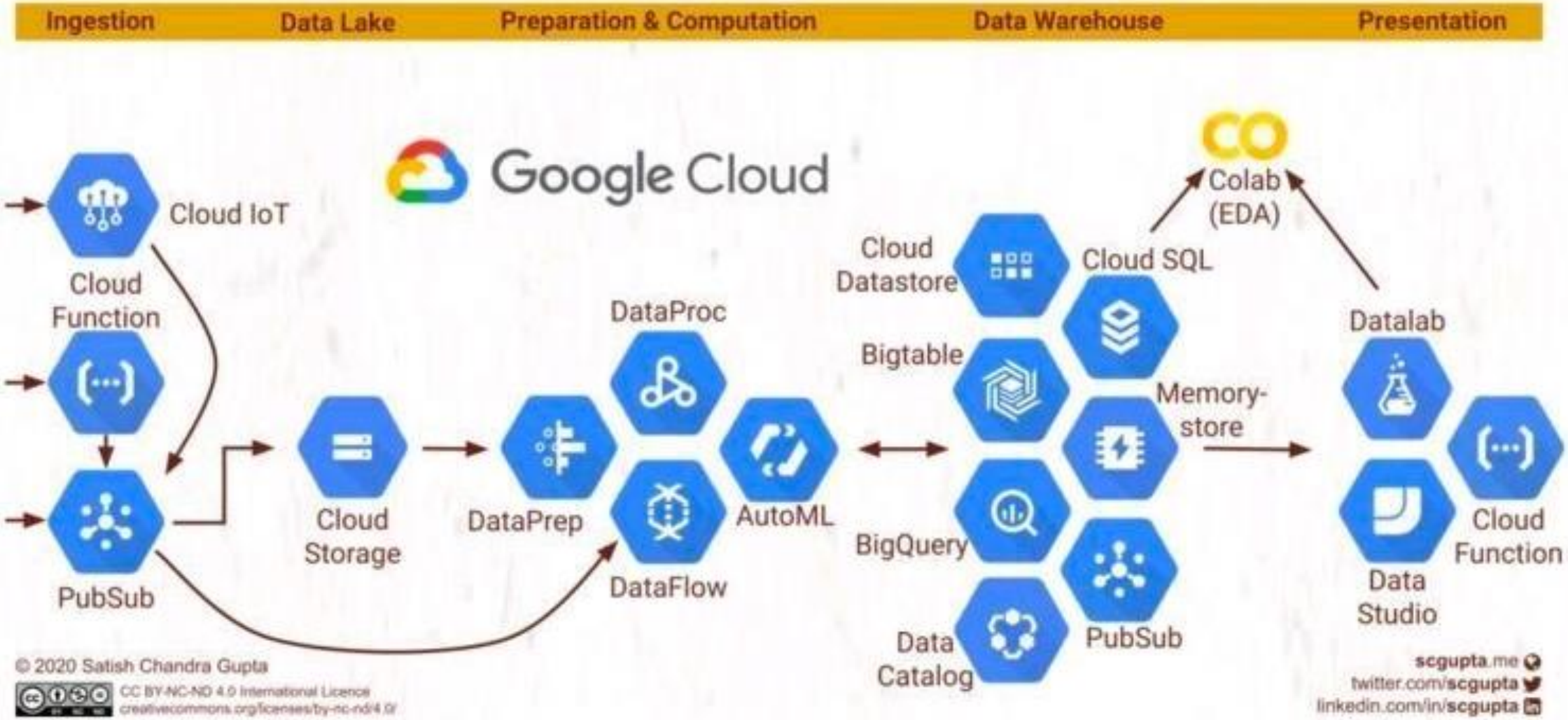
Combined Solutions



Big Data Pipelines on AWS, Microsoft Azure, and GCP

scgupta.link/big-data-pipeline




Ingestion
Data Lake
Preparation & Computation
Data Warehouse
Presentation
Google Cloud
Cloud IoT
Cloud Function
PubSub
Cloud Storage
DataPrep
DataProc
DataFlow
AutoML
Cloud Datastore
Bigtable
BigQuery
Data Catalog
Cloud SQL
Memory-store
PubSub
Colab (EDA)
Datalab
Data Studio
Cloud Function
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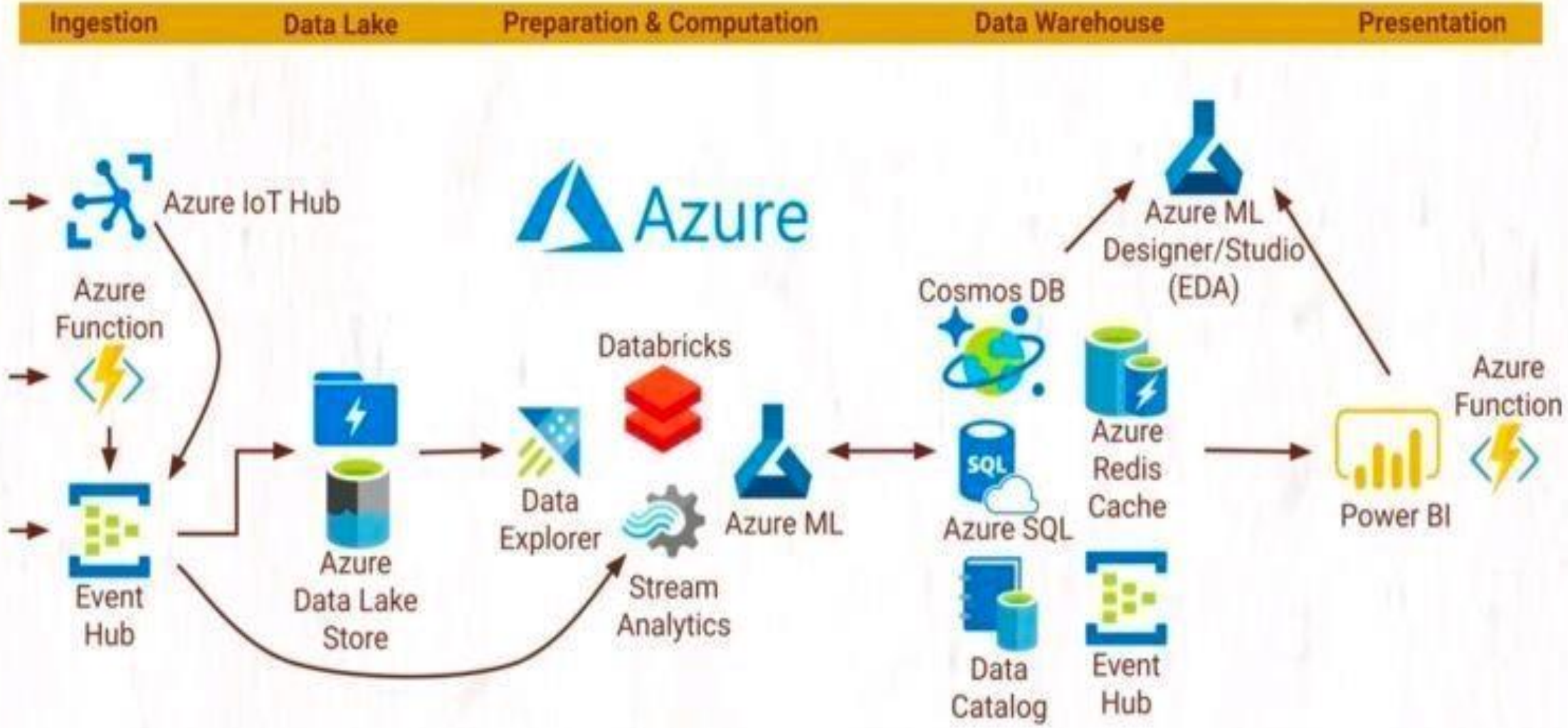
Ingestion
Data Lake
Preparation & Computation
Data Warehouse
Presentation
Azure IoT Hub
Azure Function
Event Hub
Azure Data Lake Store
Azure
Data Explorer
Databricks
Stream Analytics
Azure ML
Cosmos DB
Azure SQL
Data Catalog
Azure Redis Cache
Event Hub
Azure ML Designer/Studio (EDA)
Power BI
Azure Function

CLOUD COMPARISON

AWS VS. AZURE VS. GOOGLE

@simonholdorf

	aws	Azure	Google
Avalaible Regions	AWS Regions and Zones	Azure Regions	Google Compute Regions & Zones
Compute Services	Elastic Compute Cloud (EC2)	Virtual Machines	Compute Engine
App Hosting	Amazon Elastic Beanstalk	Azure Cloud Services	Google App Engine
Serverless Computing	AWS Lambda	Azure Functions	Google Cloud Functions
Container Support	Elastic Container Service	Azure Container Service	Container Engine
Scaling Options	Auto Scaling	Azure Autoscale	Autoscaler
Object Storage	Amazon Simple Storage (S3)	Azure Blob Storage	Cloud Storage
Block Storage	Amazon Elastic Block Storage	Azure Managed Storage	Persistent Disk
Content Delivey Network (CDN)	Amazon CloudFront	Azure CDN	Cloud CDN
SQL Database Options	Amazon RDS	Azure SQL Database	Cloud SQL
NoSQL Database Options	AWS DynamoDB	Azure DocumentDB	Cloud Datastore

CLOUD COMPARISON

AWS VS. AZURE VS. GOOGLE

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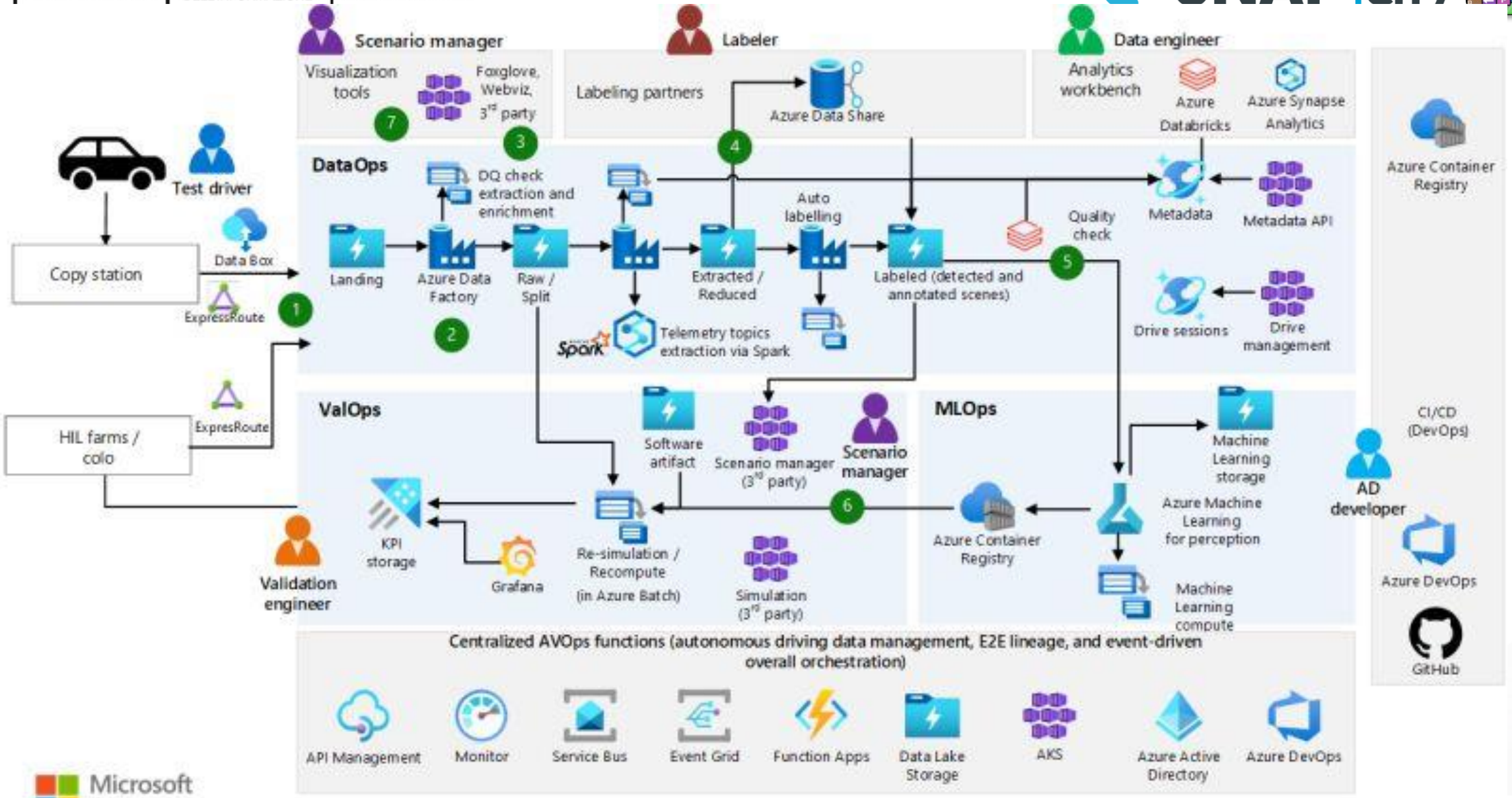
	aws	Azure	
Virtual Network	Amazon VPC	Azure Virtual Network	Cloud Virtual Network
Private Connectivity	AWS Direct Connect	Azure Express Route	Cloud Interconnect
DNS Service	Amazon Route 53	Azure Traffic Manager	Cloud DNS
Log Monitoring	Amazon CloudTrail	Azure Operational Insights	Cloud Logging
Performance Monitoring	Amazon CloudWatch	Azure Application Insights	Stackdriver Monitoring
Administration and Security	AWS Identity and Access Management (IAM)	Azure Active Directory	Cloud Identity and Access Managament (IAM)
Compliance	AWS CloudHSM	Azure Trust Center	Google Cloud Platform Security
Analytics	Amazon Kinesis	Azure Stream Analytics	Cloud Dataflow
Automation	AWS Opsworks	Azure Automation	Compute Engine Management
Management Services & Options	Amazon CloudInformation	Azure Resource Manager	Cloud Deolyment Manager
Notifications	Amazon Simple Notification Service (SNS)	Azure Notification Hub	None


Scenario manager
Visualization tools
Foxglove, Webviz, 3rd party
Labeler
Labeling partners
Azure Data Share
Data engineer
Analytics workbench
Azure Databricks
Azure Synapse Analytics
Azure Container Registry
Test driver
Copy station
Data Box
ExpressRoute
DataOps
DQ check extraction and enrichment
Landing
Azure Data Factory
Raw / Split
Extracted / Reduced
Auto labelling
Labeled (detected and annotated scenes)
Quality check
Metadata
Metadata API
Drive sessions
Drive management
Spark
Telemetry topics extraction via Spark
HIL farms / colo
ExpresRoute
ValOps
Software artifact
Scenario manager (3rd party)
Scenario manager
MLOps
Machine Learning storage
Azure Machine Learning for perception
Azure Container Registry
Machine Learning compute
AD developer
CI/CD (DevOps)
Azure DevOps
GitHub
KPI storage
Grafana
Validation engineer
Re-simulation / Recompute (in Azure Batch)
Simulation (3rd party)
Centralized AVOps functions (autonomous driving data management, E2E lineage, and event-driven overall orchestration)
API Management
Monitor
Service Bus
Event Grid
Function Apps
Data Lake Storage
AKS
Azure Active Directory
Azure DevOps
Microsoft Azure

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IoT Architectures

https://www.snap4City.org https://www.Km4City.org

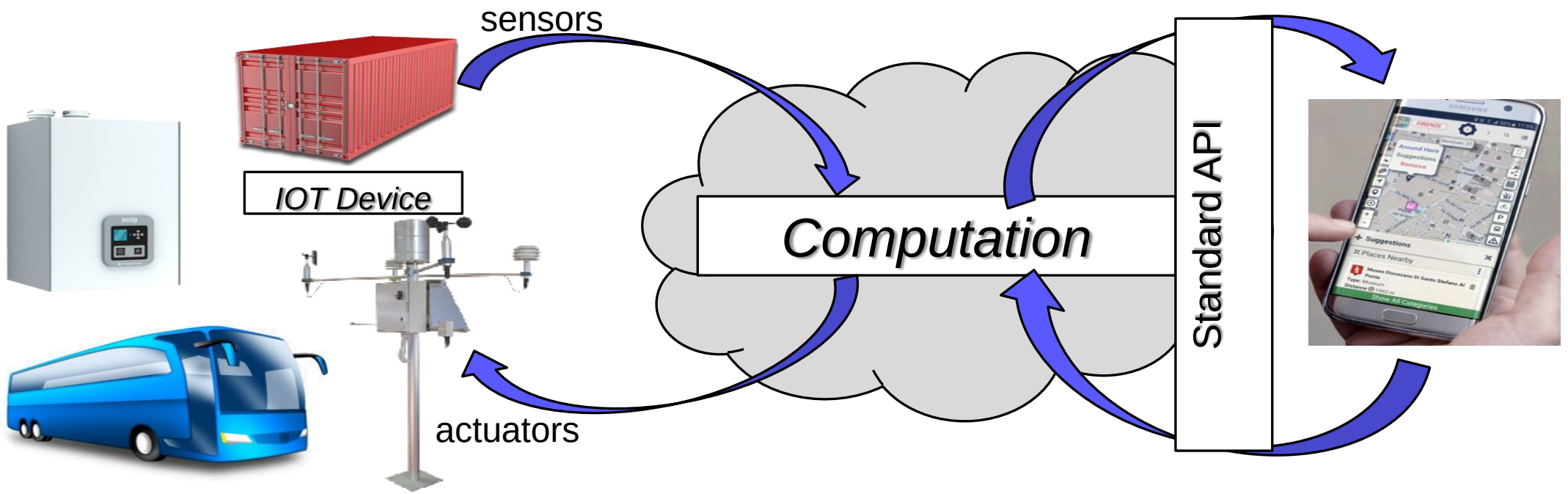
Parte: 4 (2024)

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.



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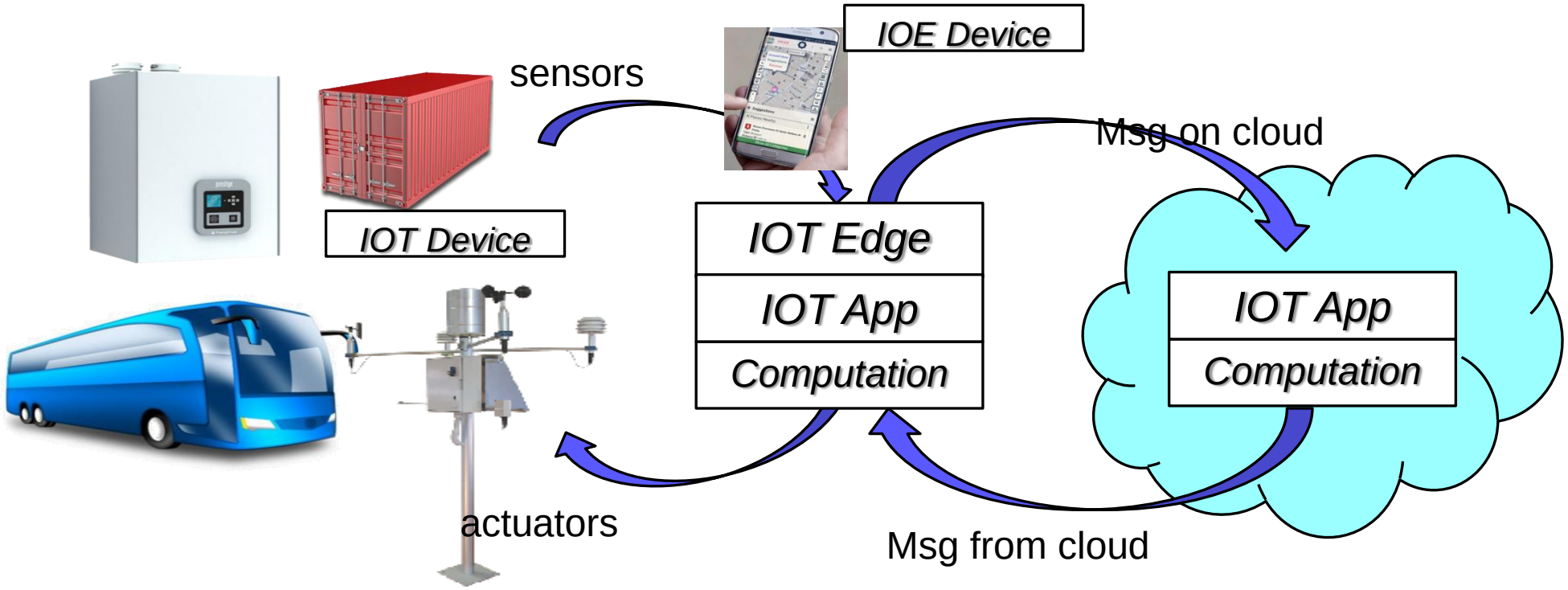
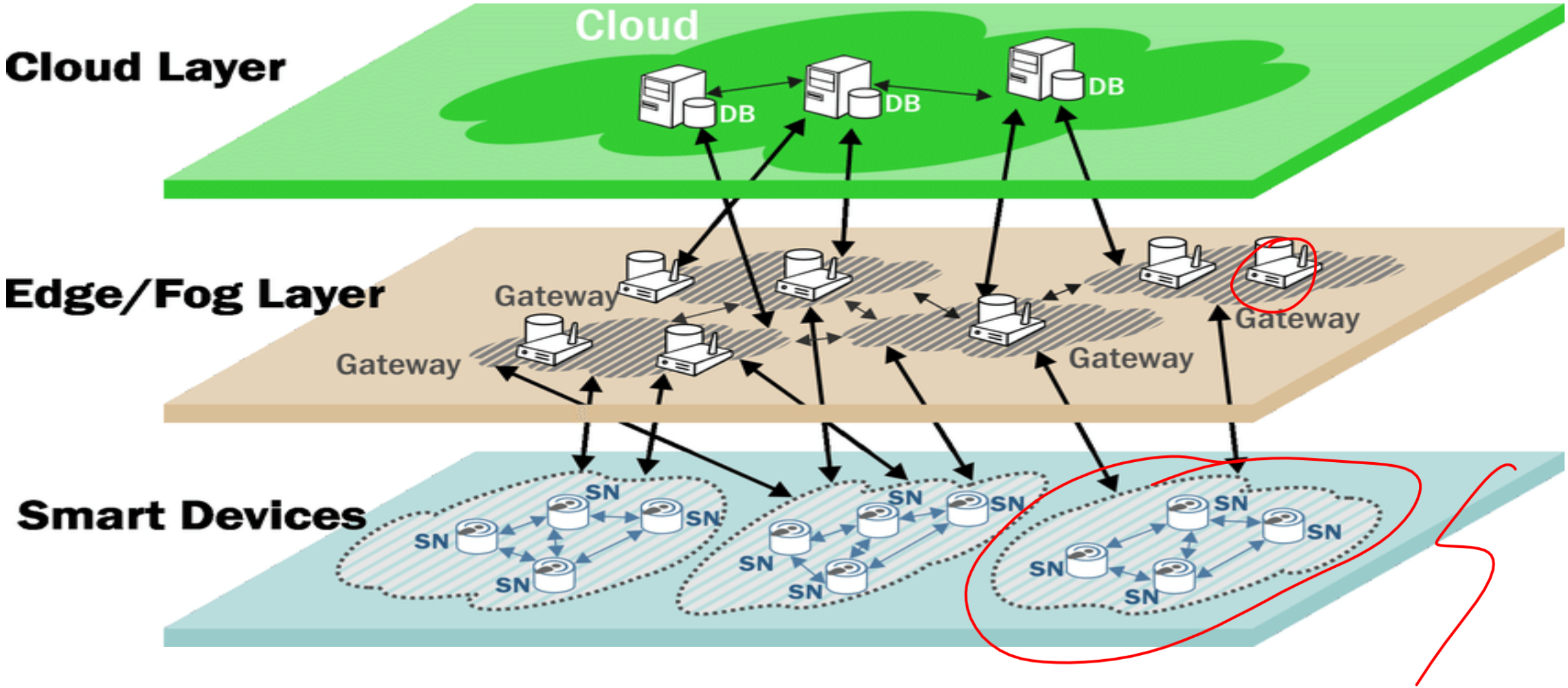
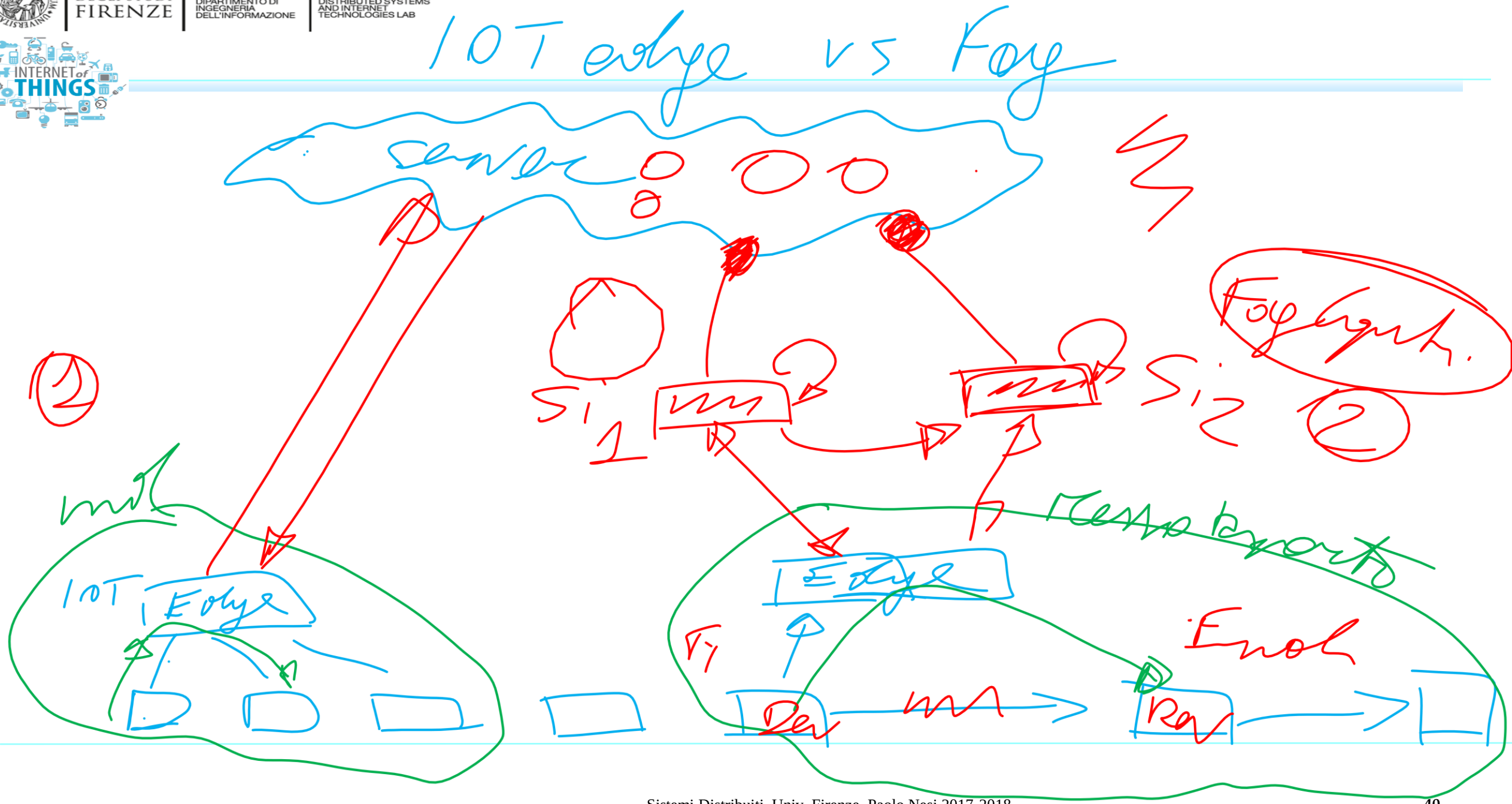


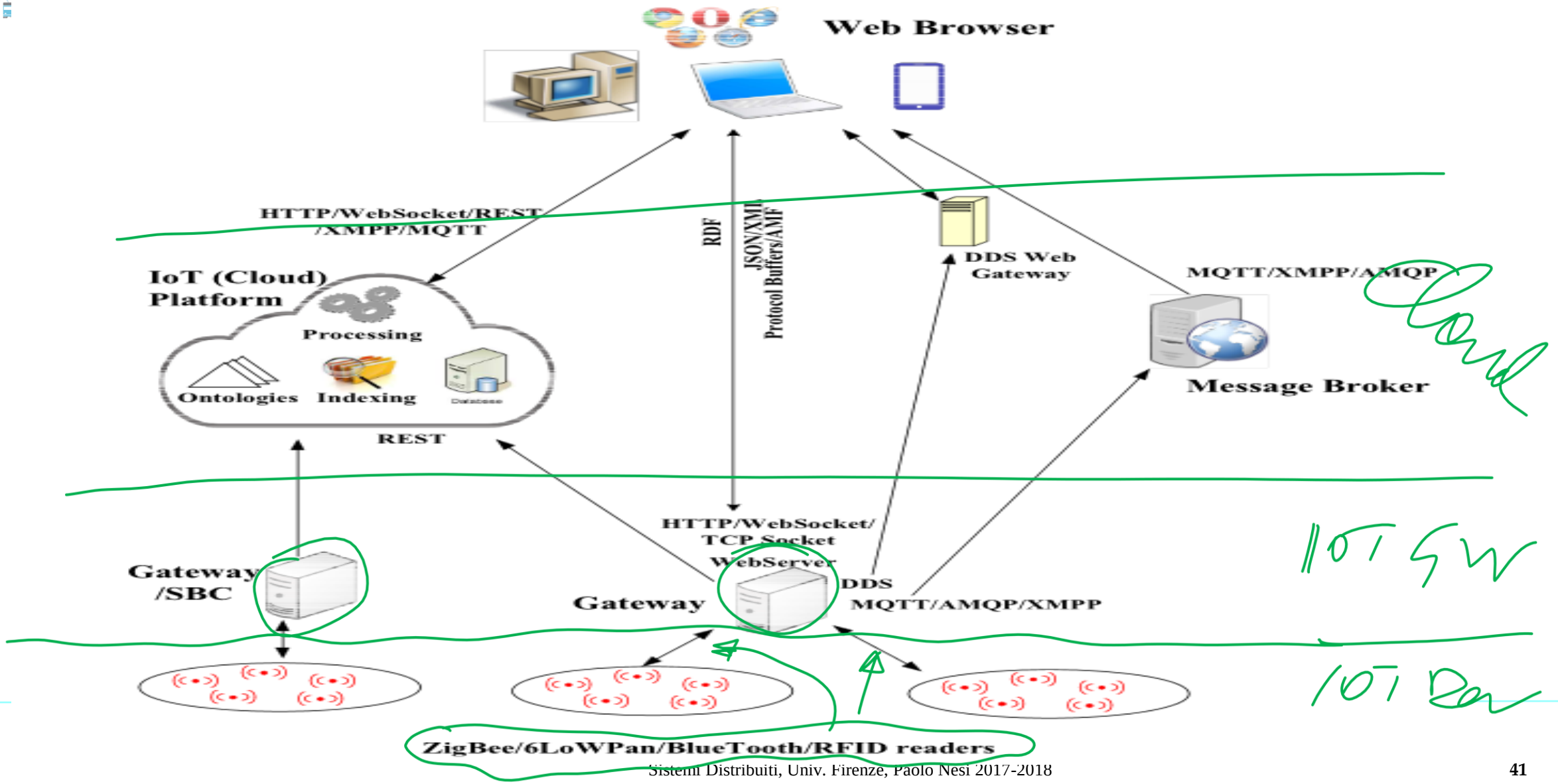
Cloud vs Fog/Edge Computing

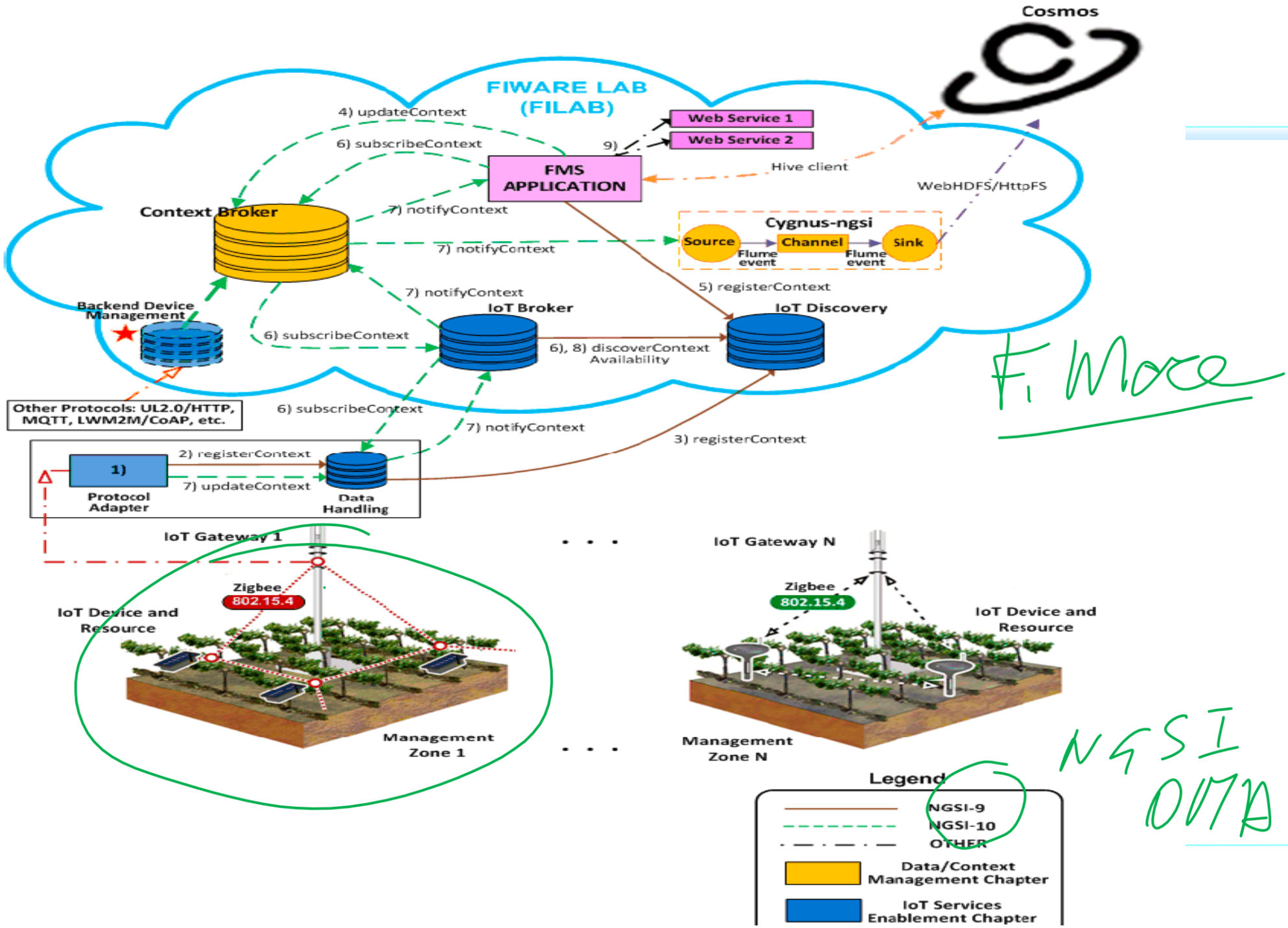


IoT edge vs Fog



Edge Computing, Fog Computing



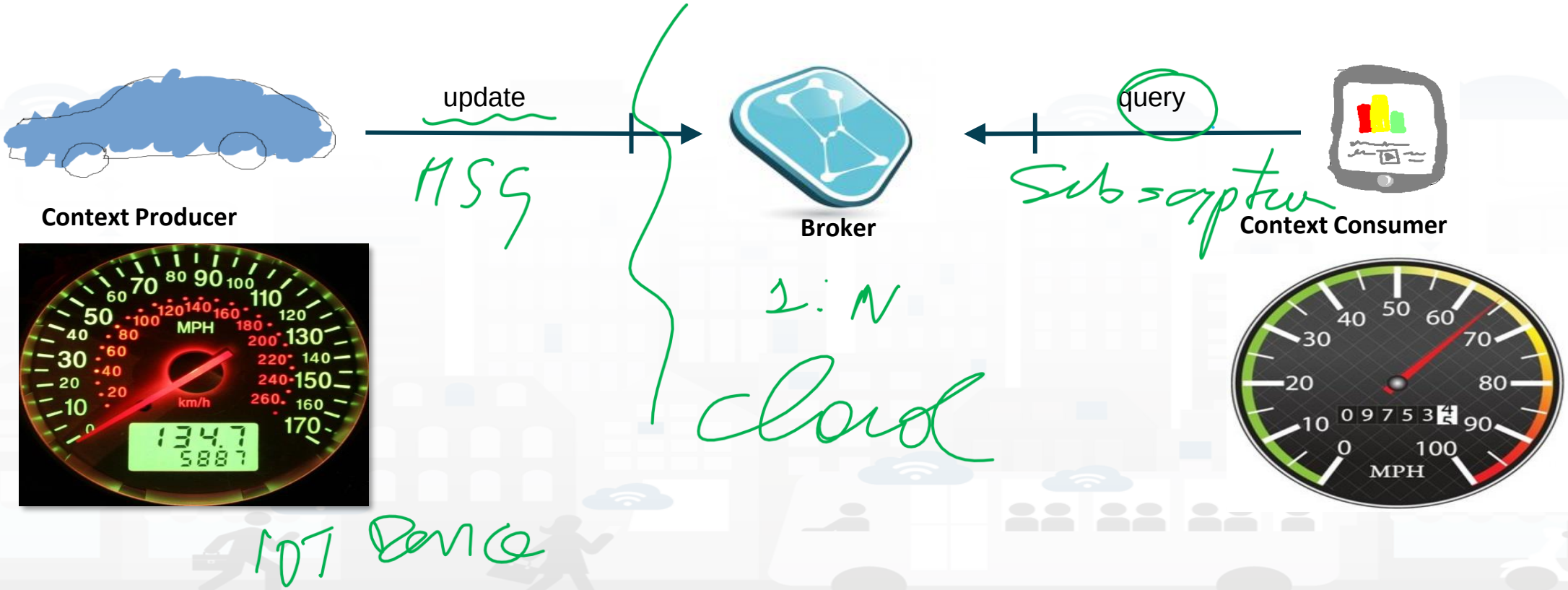


F. Mazzo

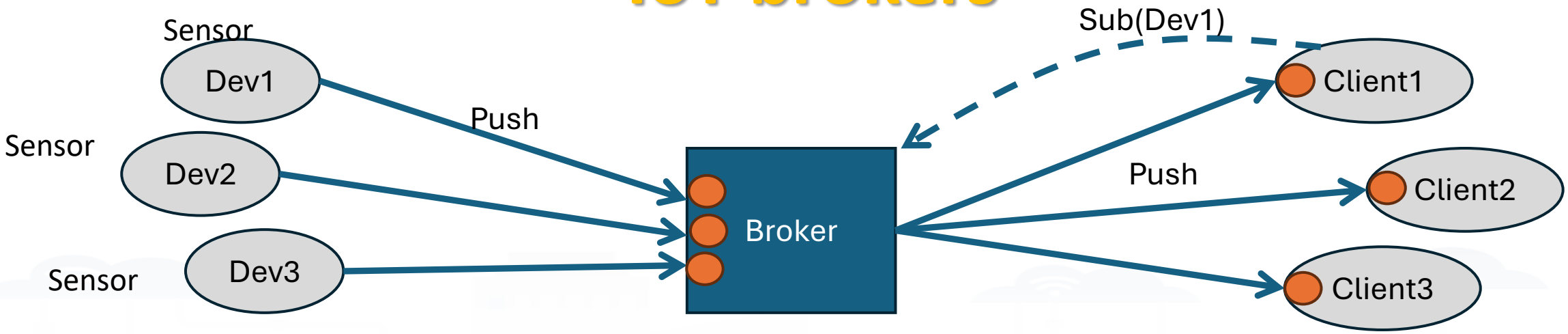
NGSI OMA

- **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

IOT Broker

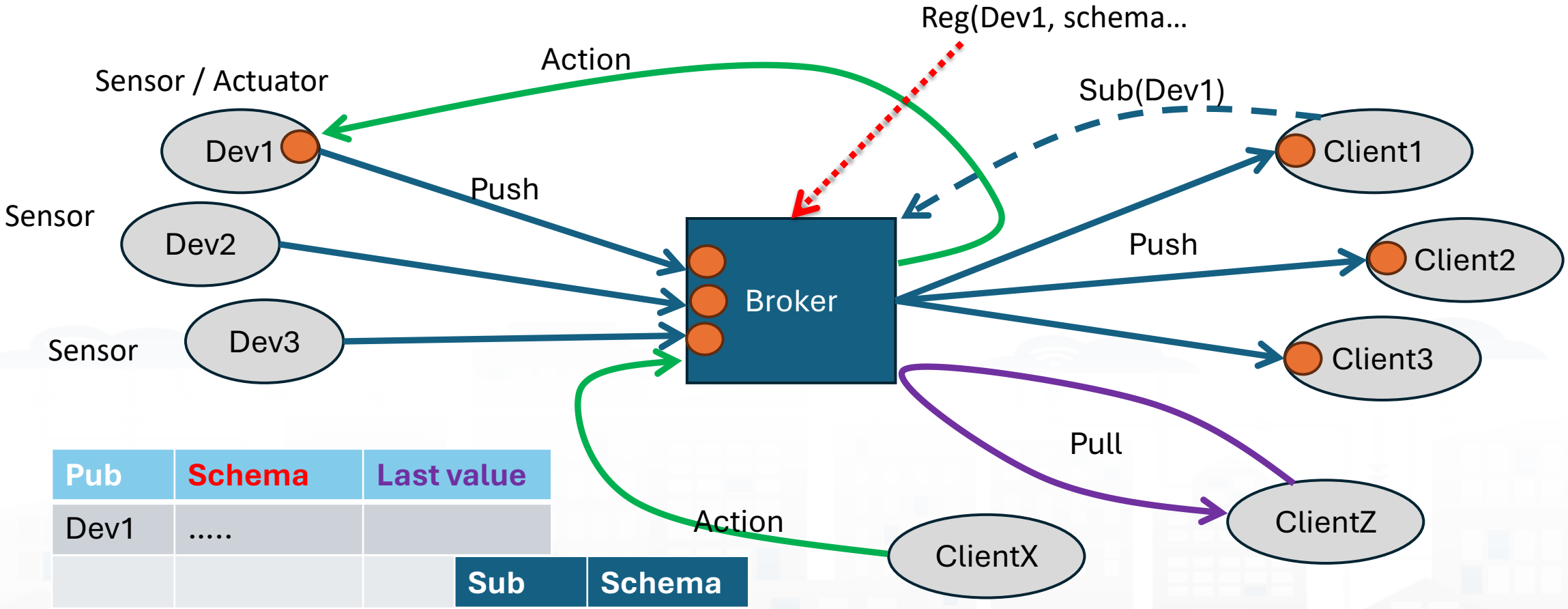


IoT brokers



Pub
Dev1

Sub	Schema
Client1	Dev1
Client1	Dev2

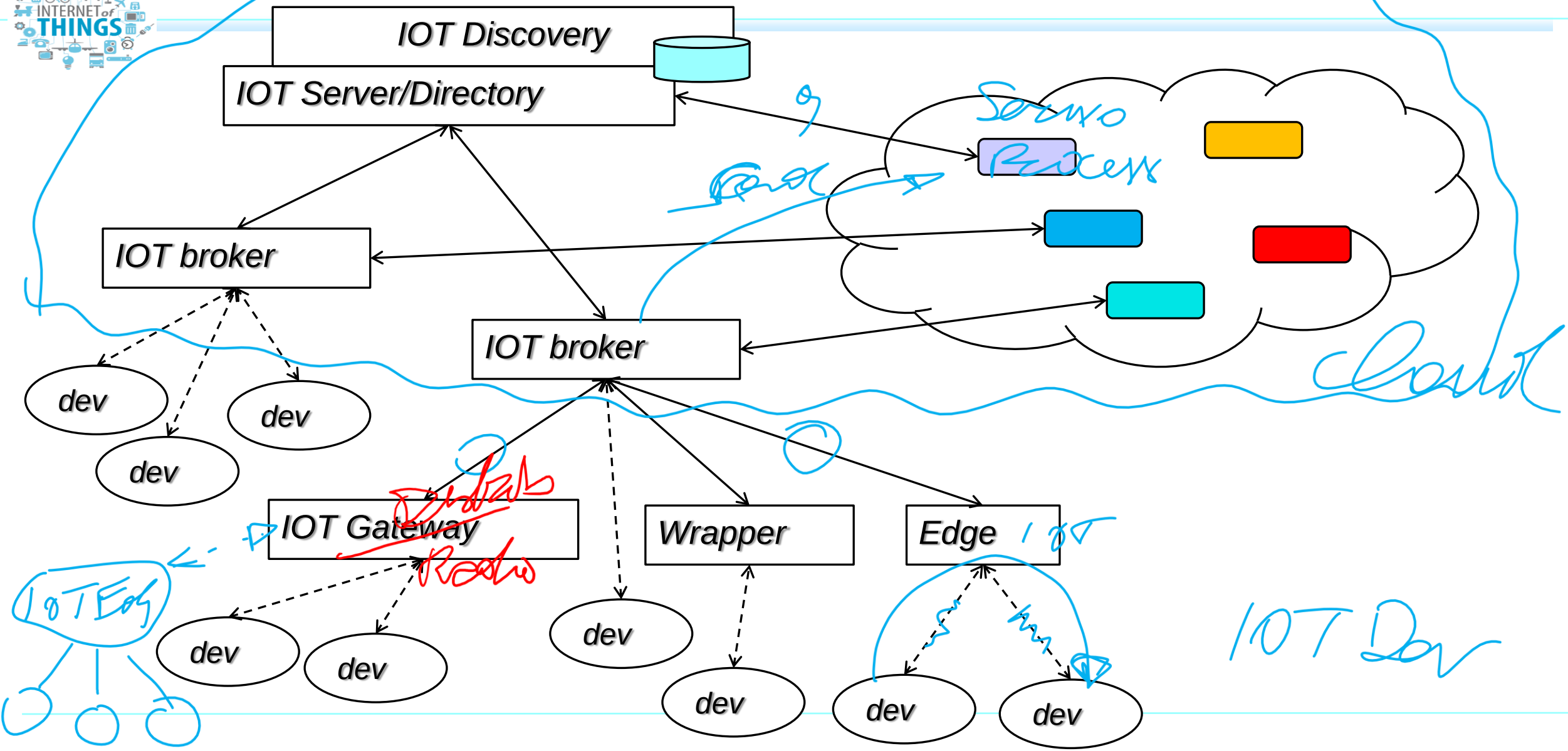


Pub	Schema	Last value
Dev1	…..	

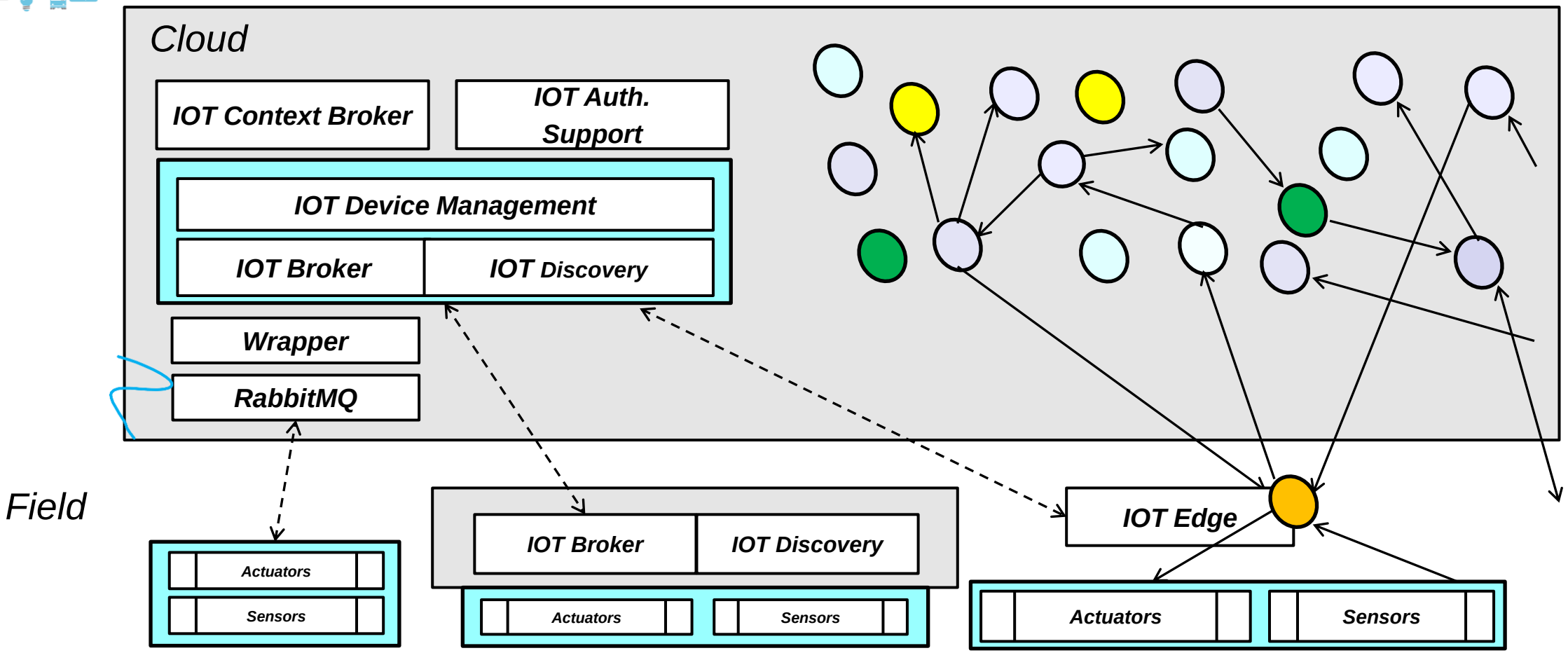
Sub	Schema
Client1	Dev1
Client1	Dev2

IoT Context Brokers

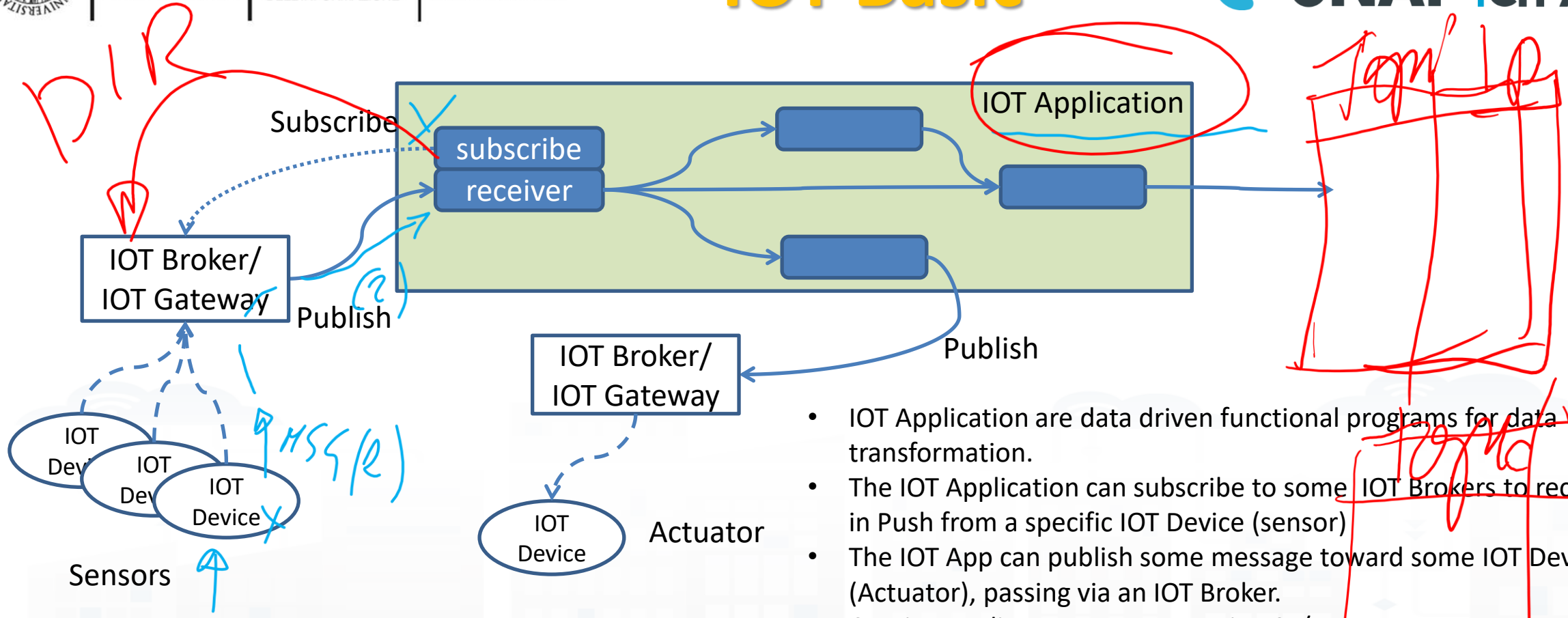
architettura



Conceptual architecture



IOT Basic

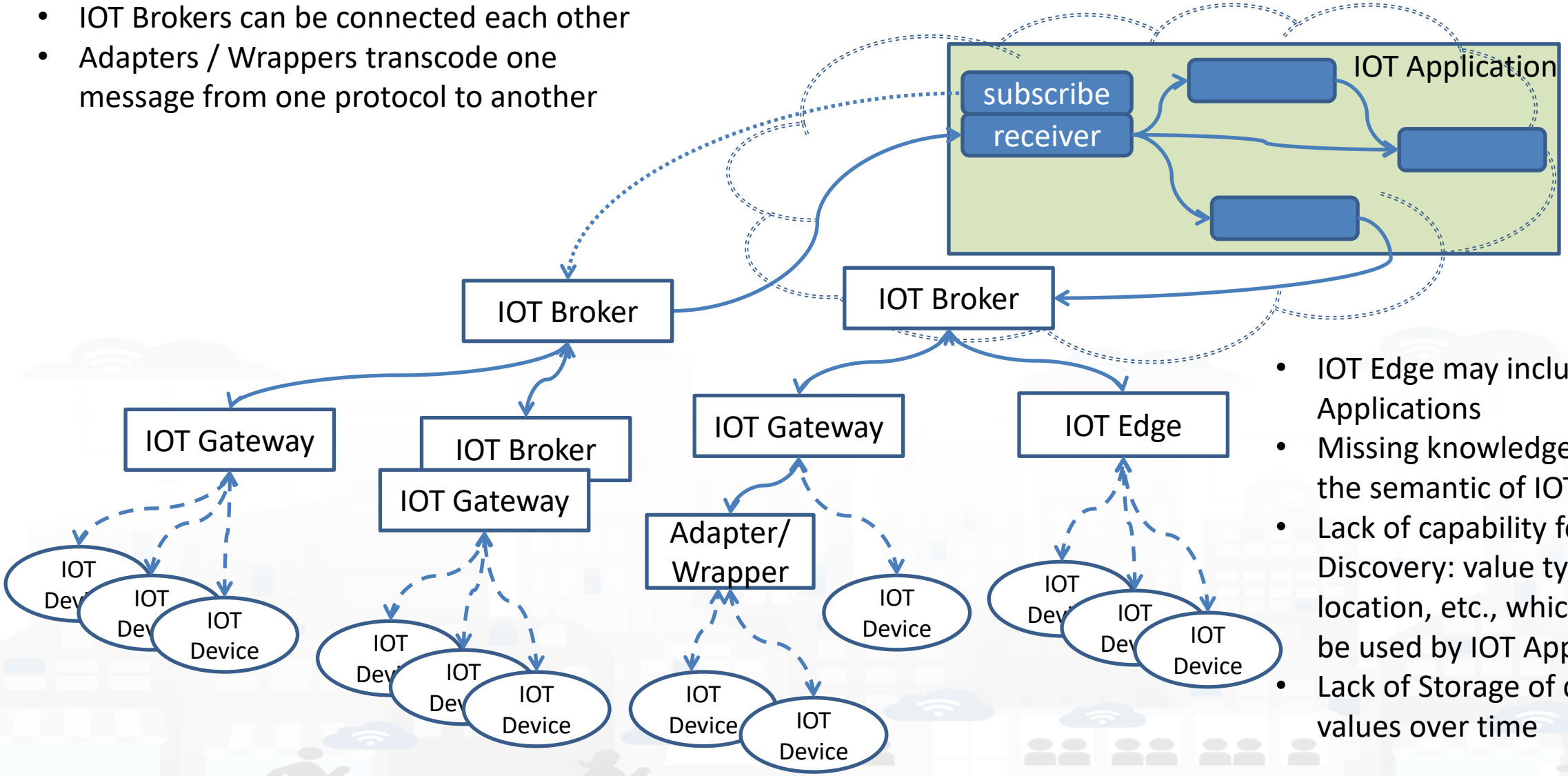


- Sensors are programmed to send data (i) periodically, or (ii) when a relevant change occurs in the sensor value, or (iii) when events occur (for example a change of status of something), etc.
- Actuator perform some action on the field: change of status, reset, turn on something, change setting value,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

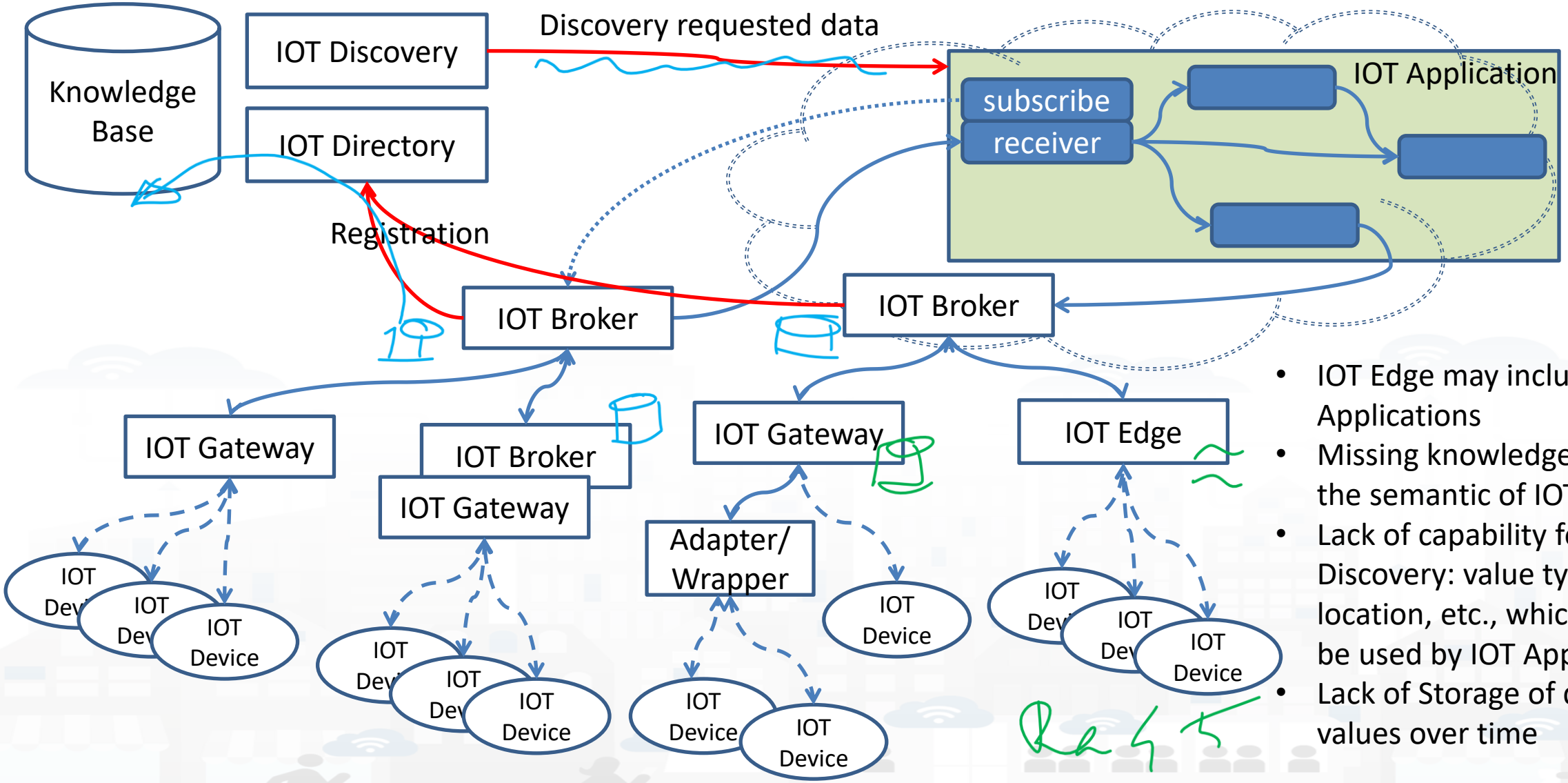
Definitions

- 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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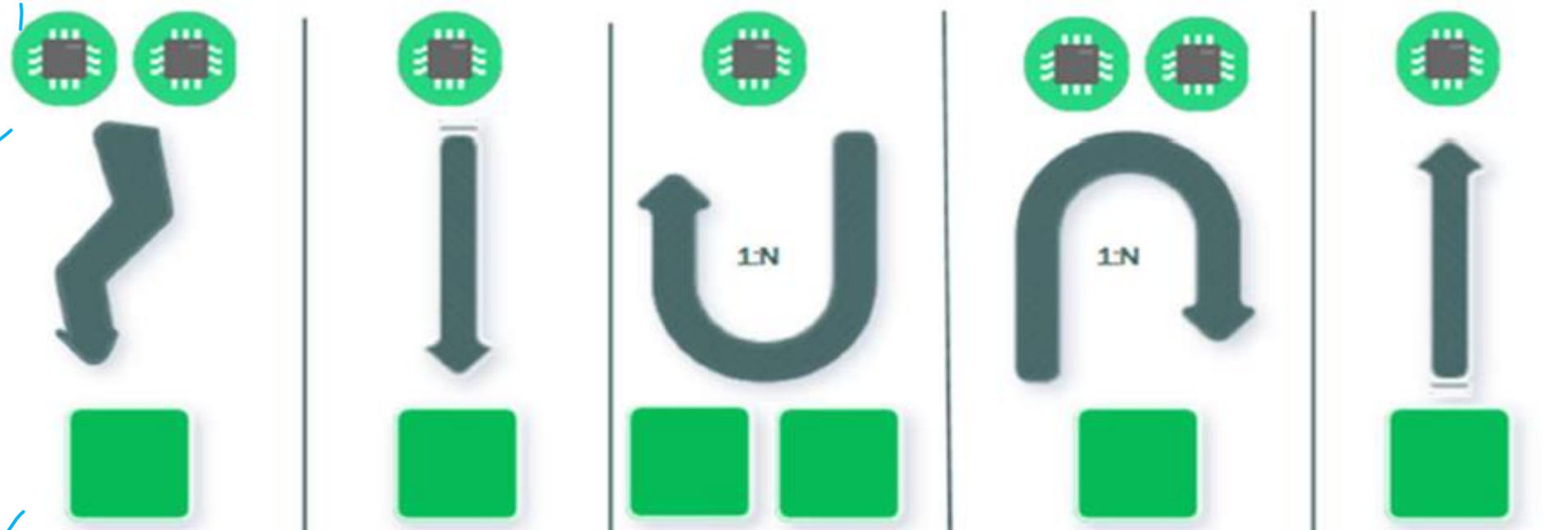
IOT/IOE Protocols

Communication Patterns



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

Registration

Push

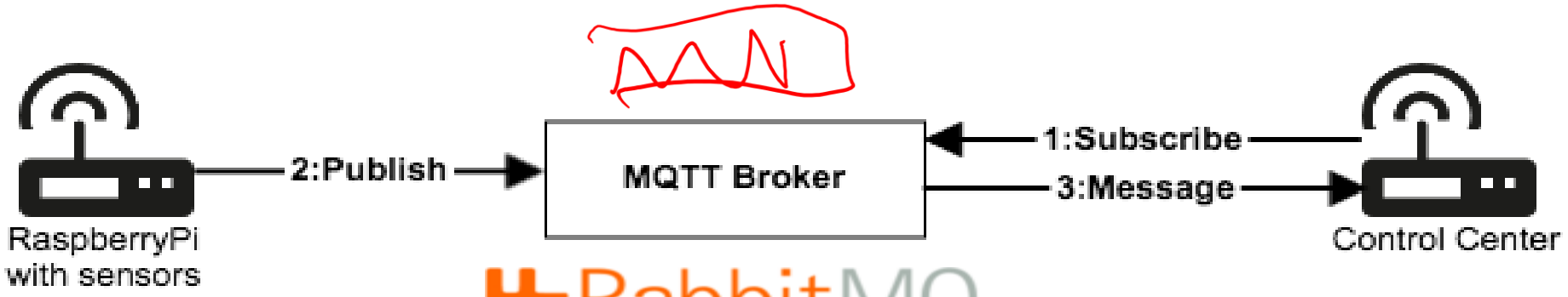
Bulk action

Note on Communication patterns

- Not all Communication Patterns are supported by all Protocols
- Protocols implement Patterns, + formats, + sequences, etc.
- They are referred at level of communications
  - IOT Device ← → IOT Gateway ←→IOT Broker
- IOT Protocols mostly used at level of IP are:
  - NGSI V1/2, MQTT, COAP, AMQP, OneM2M, WS, ModBUS,
- Radio protocols are: Lora, ZigBee, 3G, Wi-Fi, etc.
- Formats: JSON, Geo-JSON, Linked Data, XML, CSV,

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



IOT stack protocols

			Security	Management
Session		MQTT, SMQTT, CoRE, DDS, AMQP , XMPP, CoAP, …	TCG, Oath 2.0, SMACK, SASL, ISASecure, ace, DTLS, Dice, …	IEEE 1905, IEEE 1451, …
Network	Encapsulation	6LowPAN, 6TiSCH, 6Lo, Thread, …		
	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, …		

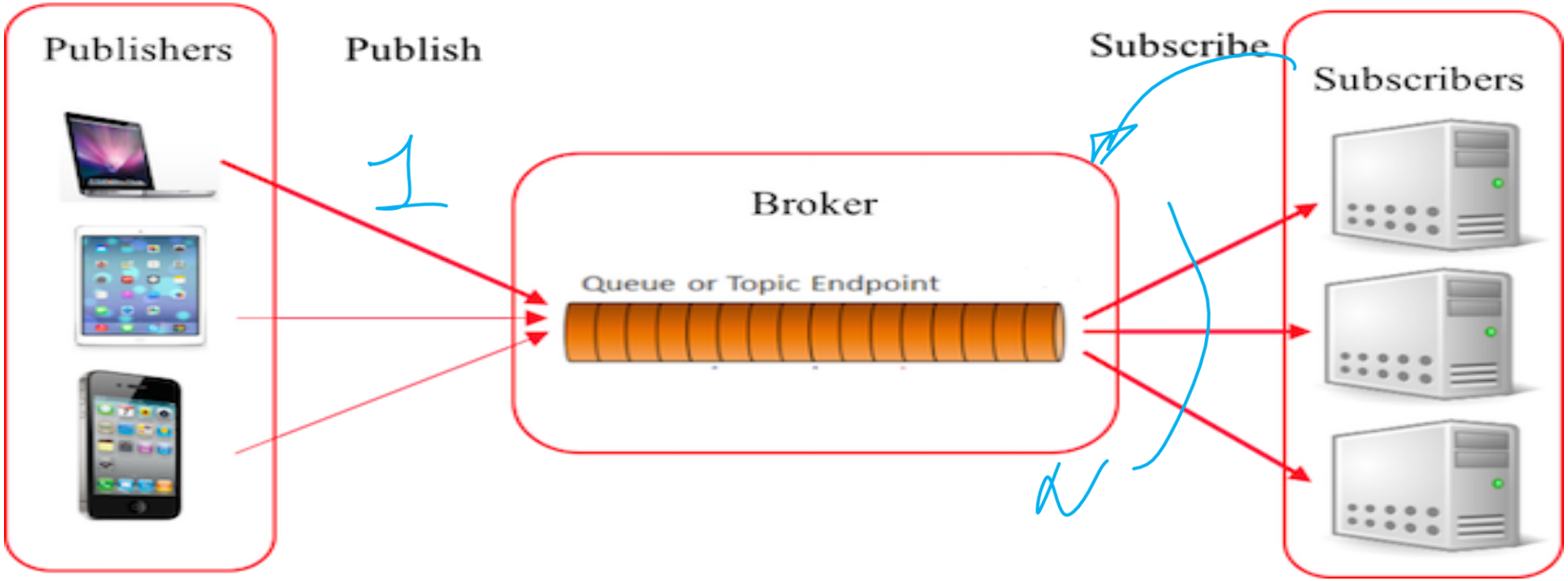
https://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/

Comparison high level IOT protocols

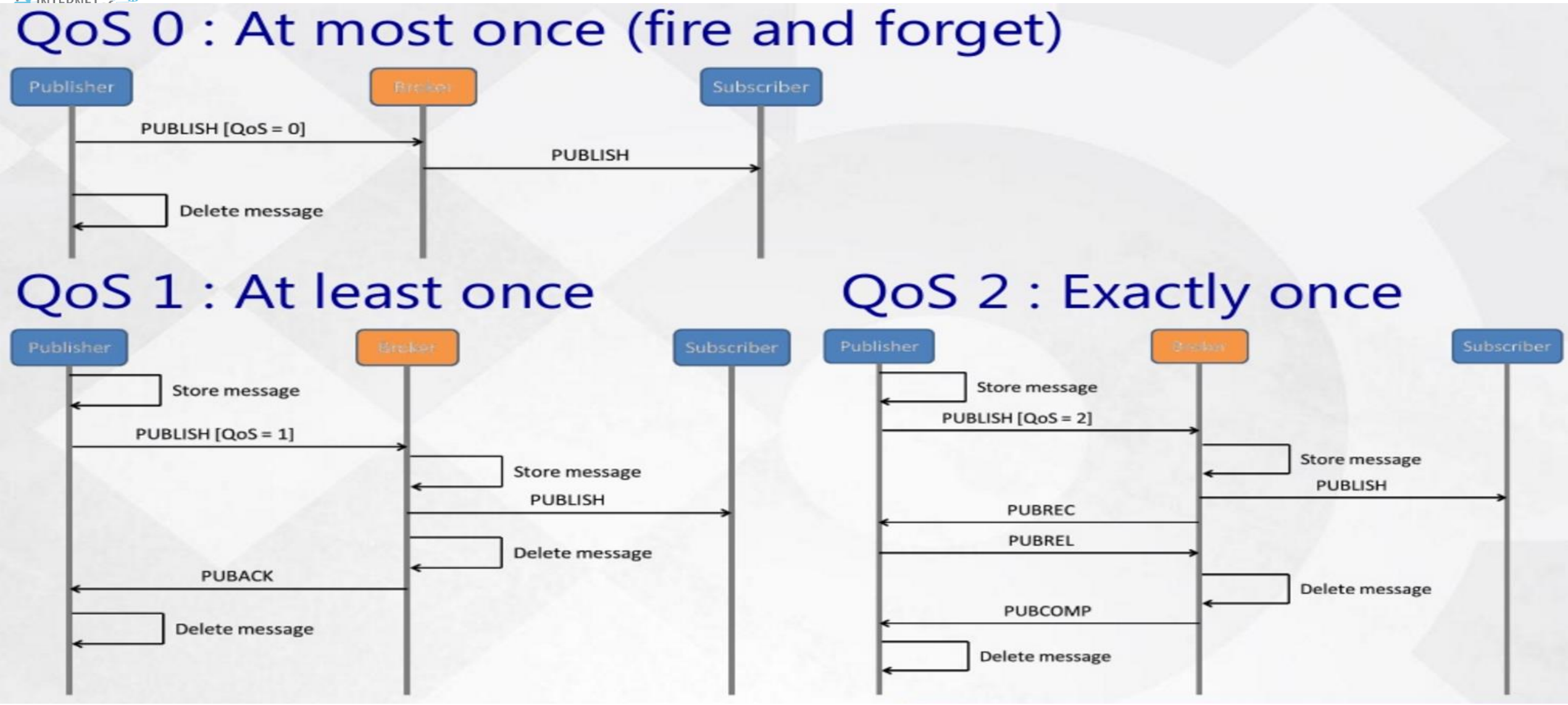
Protocols	UDP/TCP	Architecture	Security and QoS	Header Size (bytes)	Max Length(bytes)
MQTT	TCP	Pub/Sub	Both	2	5
AMQP	TCP	Pub/Sub	Both	8	-
CoAP	UDP	Req/Res	Both	4	20 (typical)
XMPP	TCP	Both	Security	-	-
DDS	TCP/UDP	Pub/Sub	QoS	-	-
NGSI	TCP/IP				

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)

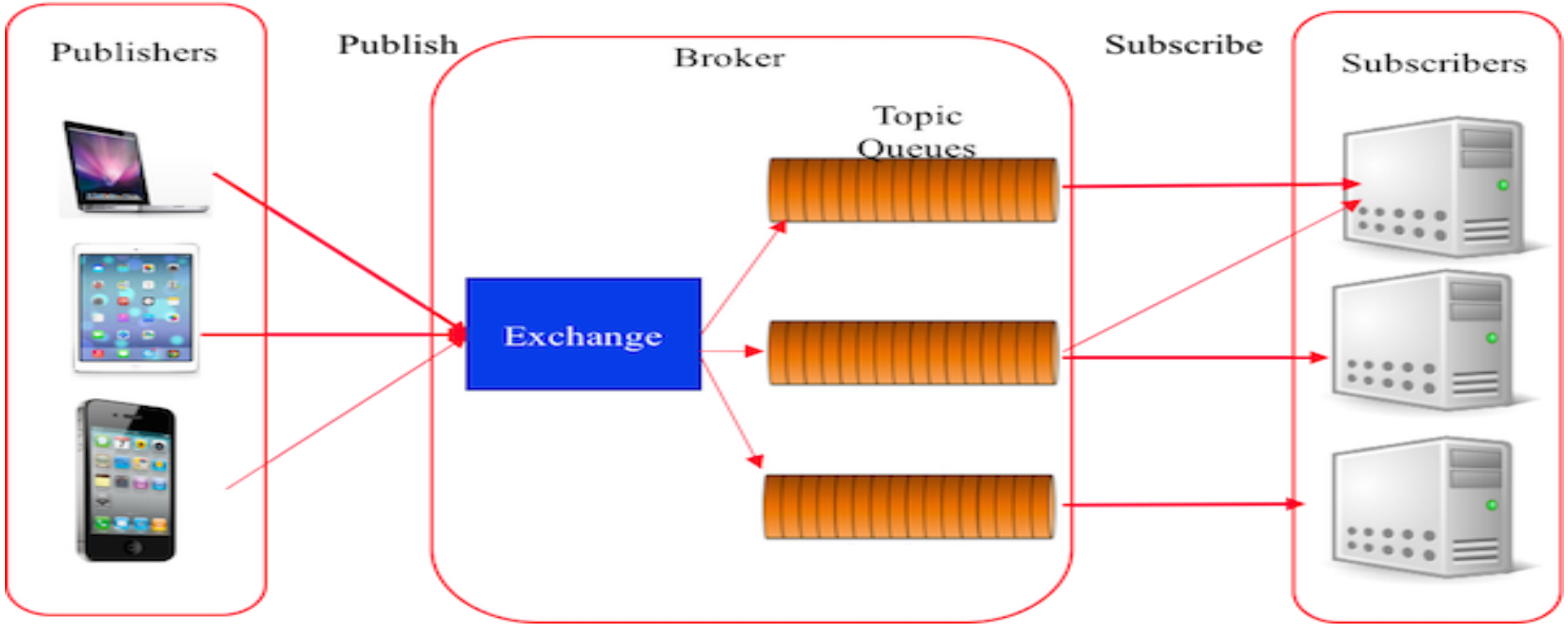


MQTT QoS


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

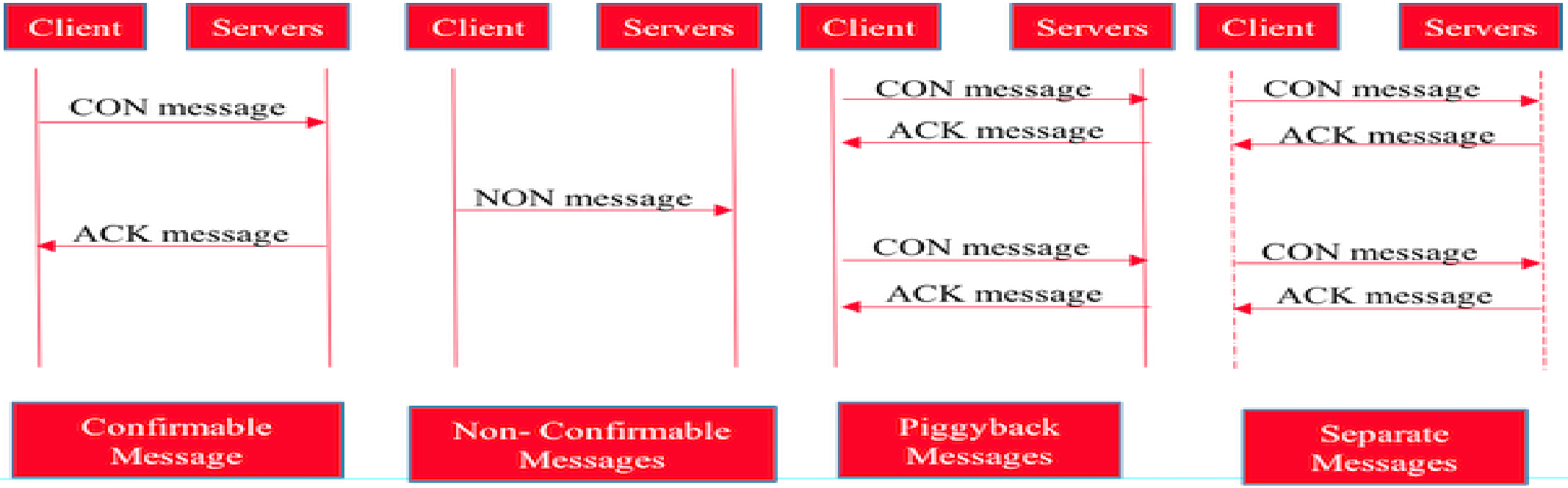
AMQP Advanced Message Queuing Protocol

- 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

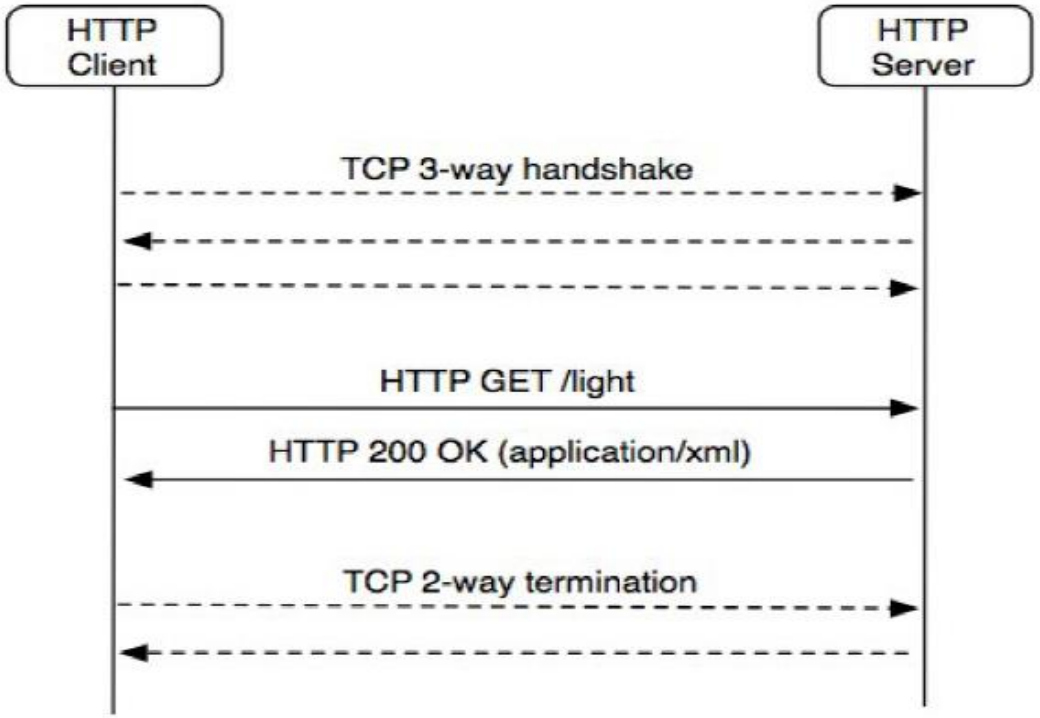
Main protocols

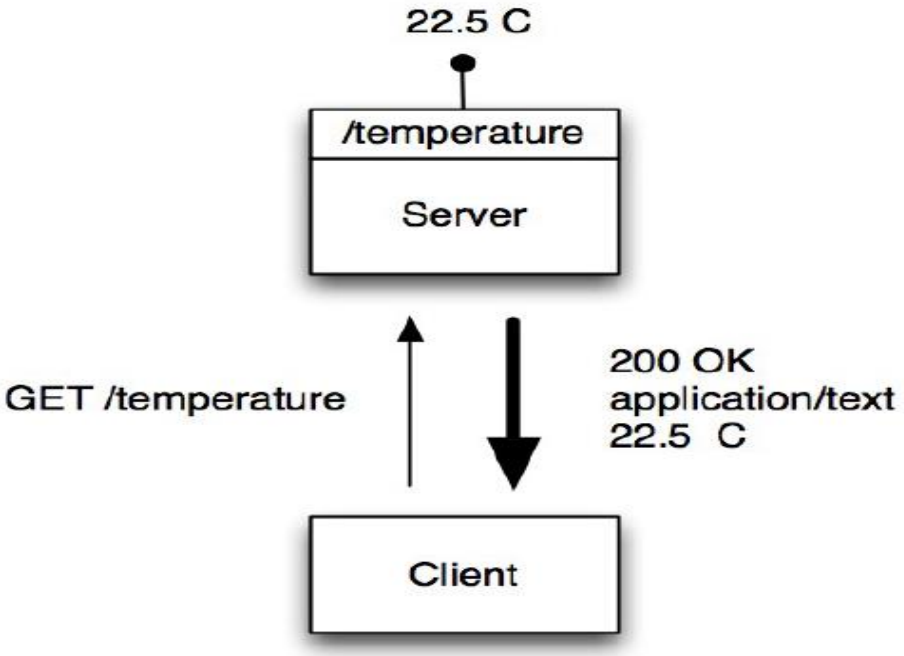
Protocol	How does It Work?	Use Cases
HTTP	TCP Connection HTTP REQ HTTP RESP	Web Browsing
HTTP/3 (QUIC)	UDP Connection	IoT, Virtual Reality
HTTPS	TCP Connection public key session key encrypted data	Web Browsing
WebSocket	HTTP Upgrade Full Duplex	Live Chat, Real-Time Data Transmission
TCP	SYN SYN + ACK ACK	Web Browsing, Email Protocols
UDP	REQUEST RESPONSE	Video Conferencing
SMTP	sender, SMTP Server, receiver	Sending/Receiving Emails
FTP	Control Channel Data Channel	Upload/Download Files

Create	→	POST
Read	→	GET
Update	→	PUT
Delete	→	DELETE

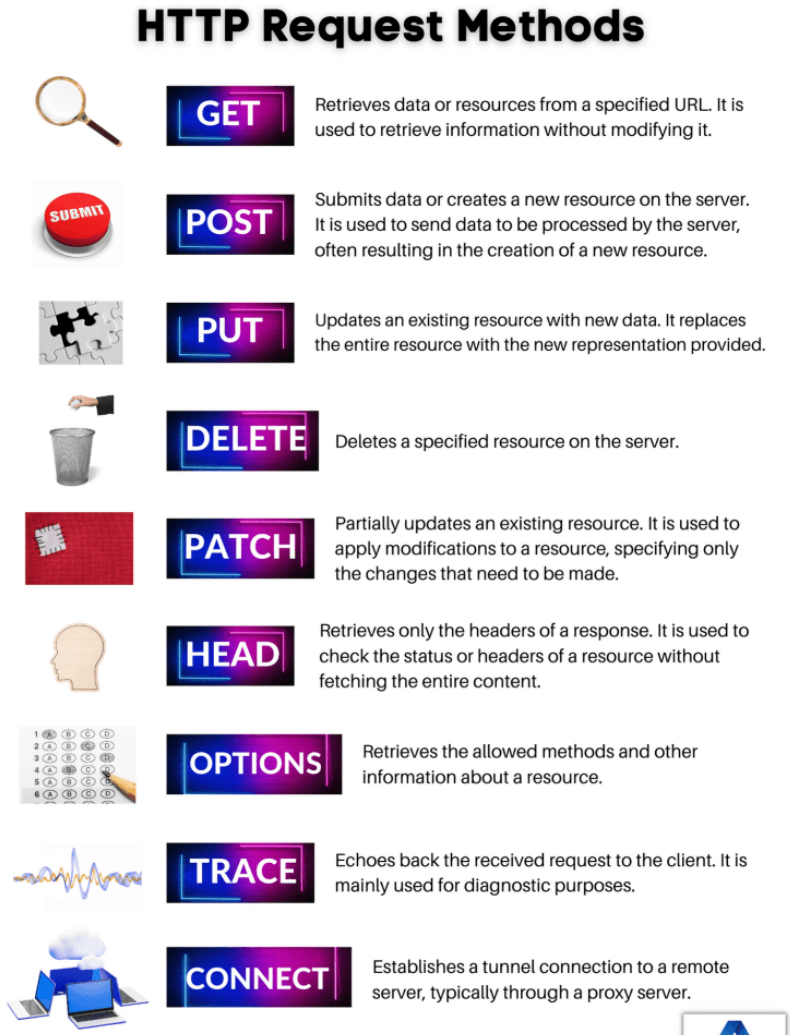
HTTP Methods

HTTP GET


HTTP Client
HTTP Server
TCP 3-way handshake
HTTP GET /light
HTTP 200 OK (application/xml)
TCP 2-way termination


22.5 C
/temperature
Server
GET /temperature
200 OK
application/text
22.5 C
Client

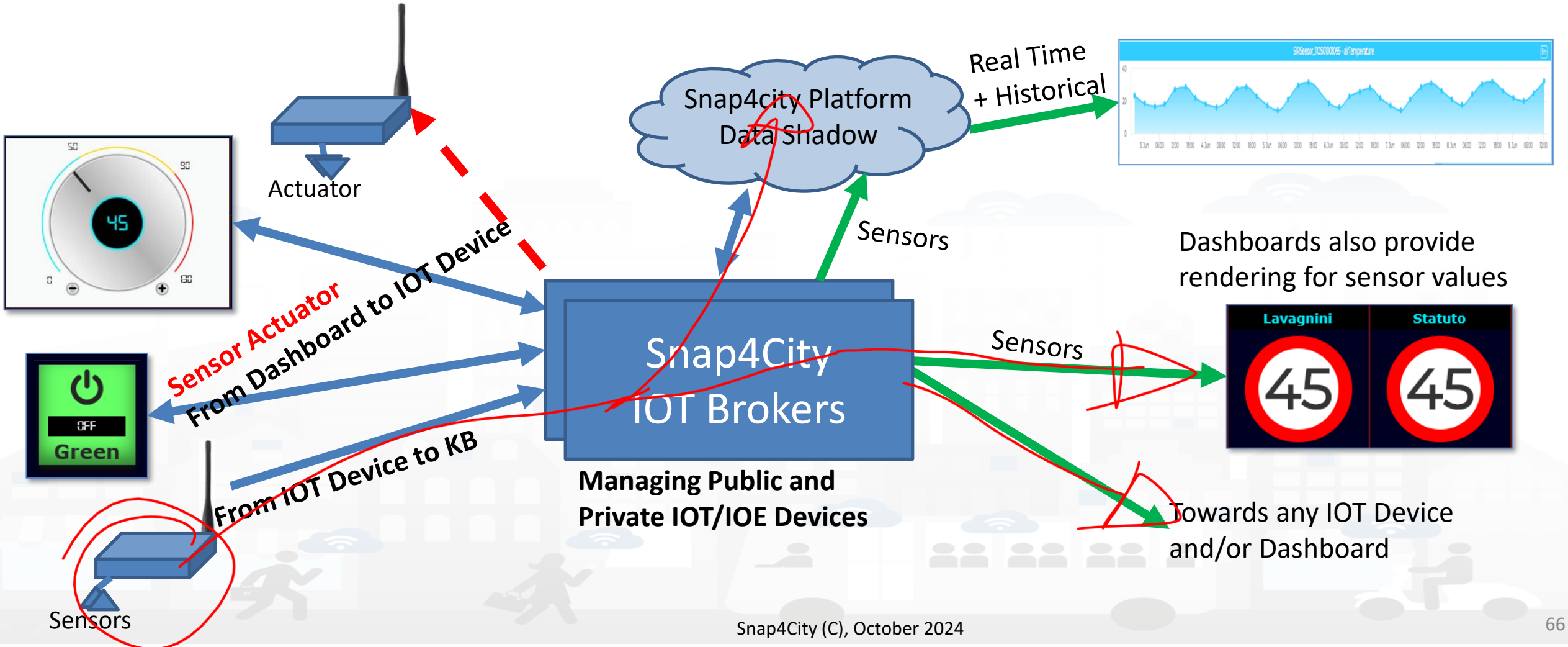
HTTP Method	Request has body	Response has body	Safe	Idempotent	Cachable
GET	NO	YES	YES	YES	YES
POST	YES	YES	NO	NO	YES
PUT	YES	YES	NO	YES	NO
DELETE	YES	YES	NO	YES	NO
TRACE	NO	YES	YES	YES	NO
OPTIONS	NO	YES	YES	YES	NO
CONNECT	NO	YES	NO	NO	NO
PATCH	YES	YES	NO	NO	NO



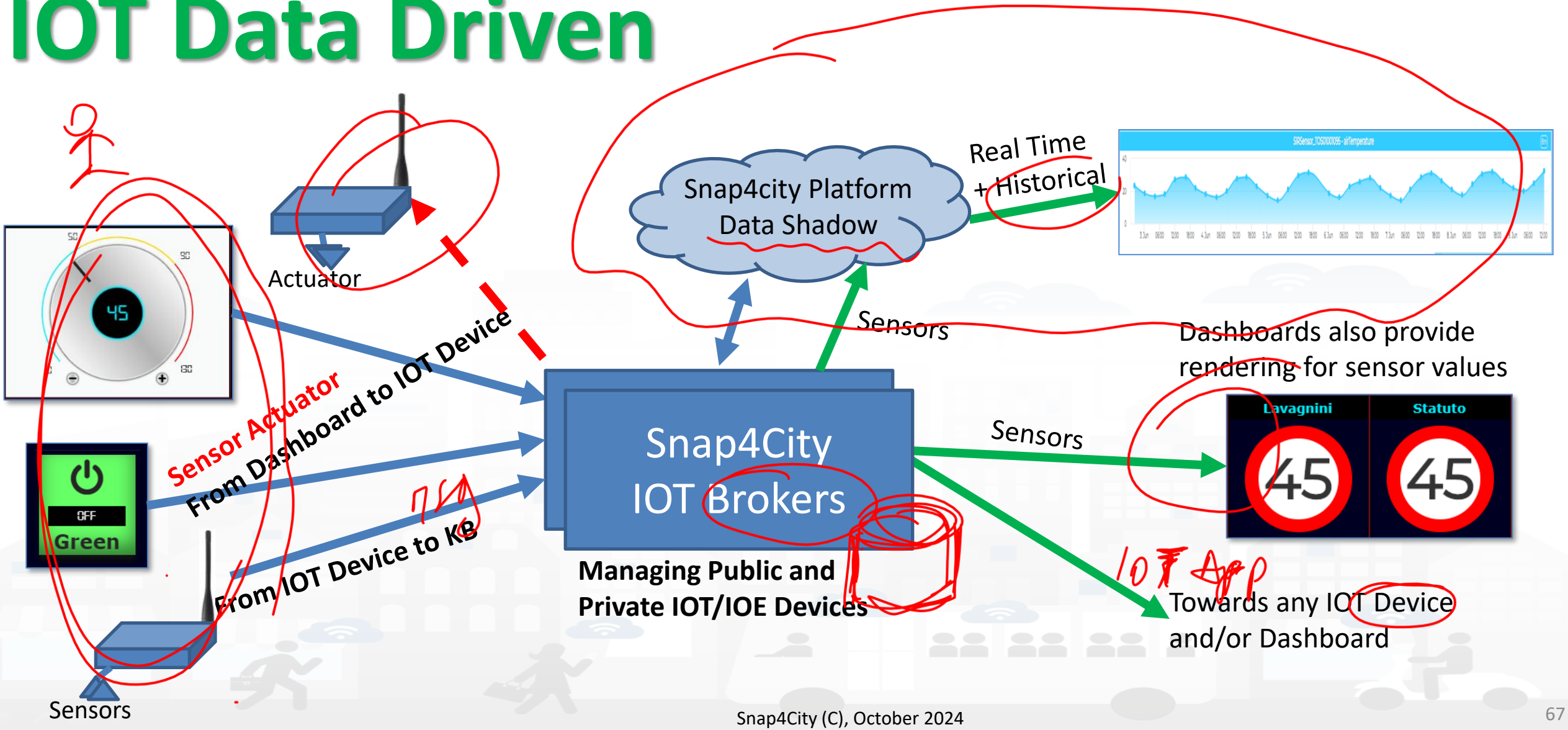
http GET vs POST

	GET	POST
BACK button/Reload	Harmless	Data will be re-submitted (the browser should alert the user that the data are about to be re-submitted)
Bookmarked	Can be bookmarked	Cannot be bookmarked
Cached	Can be cached	Not cached
Encoding type	application/x-www-form-urlencoded	application/x-www-form-urlencoded or multipart/form-data. Use multipart encoding for binary data
History	Parameters remain in browser history	Parameters are not saved in browser history
Restrictions on data length	Yes, when sending data, the GET method adds the data to the URL; and the length of a URL is limited (maximum URL length is 2048 characters)	No restrictions
Restrictions on data type	Only ASCII characters allowed	No restrictions. Binary data is also allowed
Security	GET is less secure compared to POST because data sent is part of the URL Never use GET when sending passwords or other sensitive information!	POST is a little safer than GET because the parameters are not stored in browser history or in web server logs
Visibility	Data is visible to everyone in the URL	Data is not displayed in the URL

IOT Data Driven



IOT Data Driven



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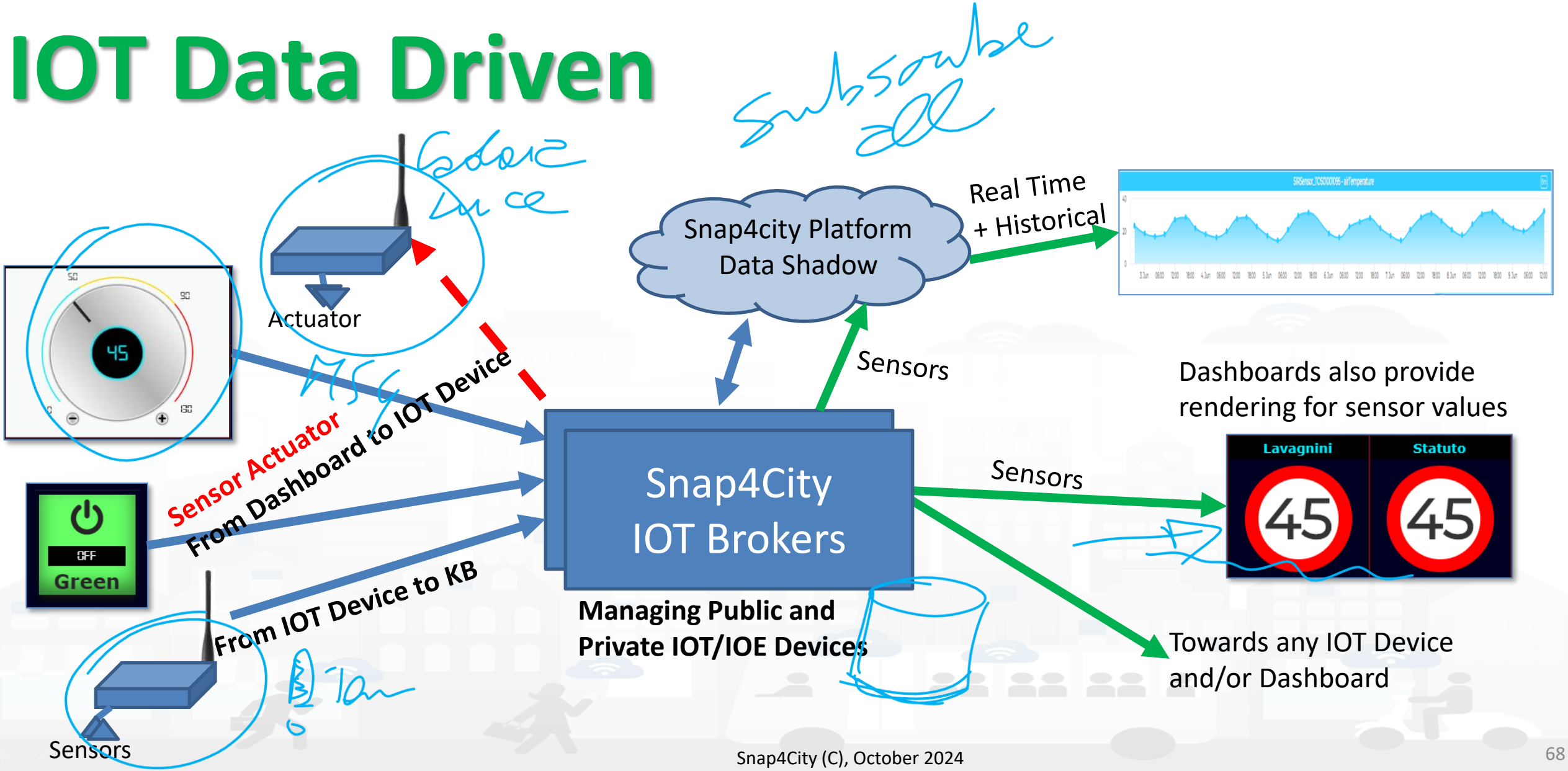

IOT Architectures Comparison

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

Market Solutions

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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
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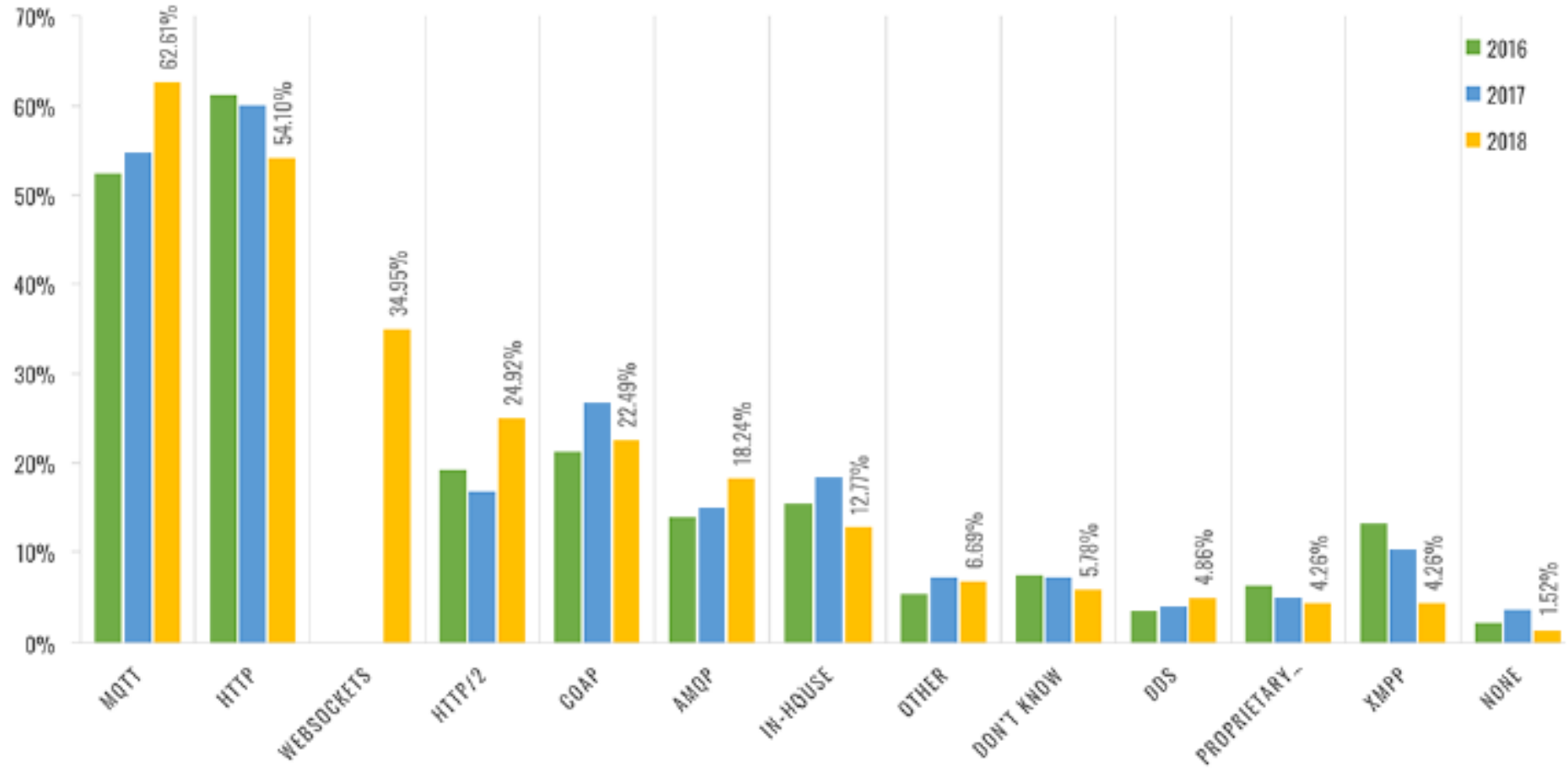
IOT IGNITE [57]	N	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N	Y	MQTT
FIWARE [47]	N	Y	N	Y	N	N	N	Y	N	Y	(Y)	(N)	Y	N	Y	N	N	Y	Y
ARM mbed IoT [48]	Y	Y	Y	Y	Y	N	(N)	N	Y	Y	Y	N	N	N	Y	N	N	Y	Limited
Airvantage [51]	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	Y	MQTT, HTTP
AWS [43]	Y	Y	Y	Y	N	Y	(N)	Y	Y	N	Y	N	N	N	Y	Y	(Y)	Y	Limited
Azure 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.

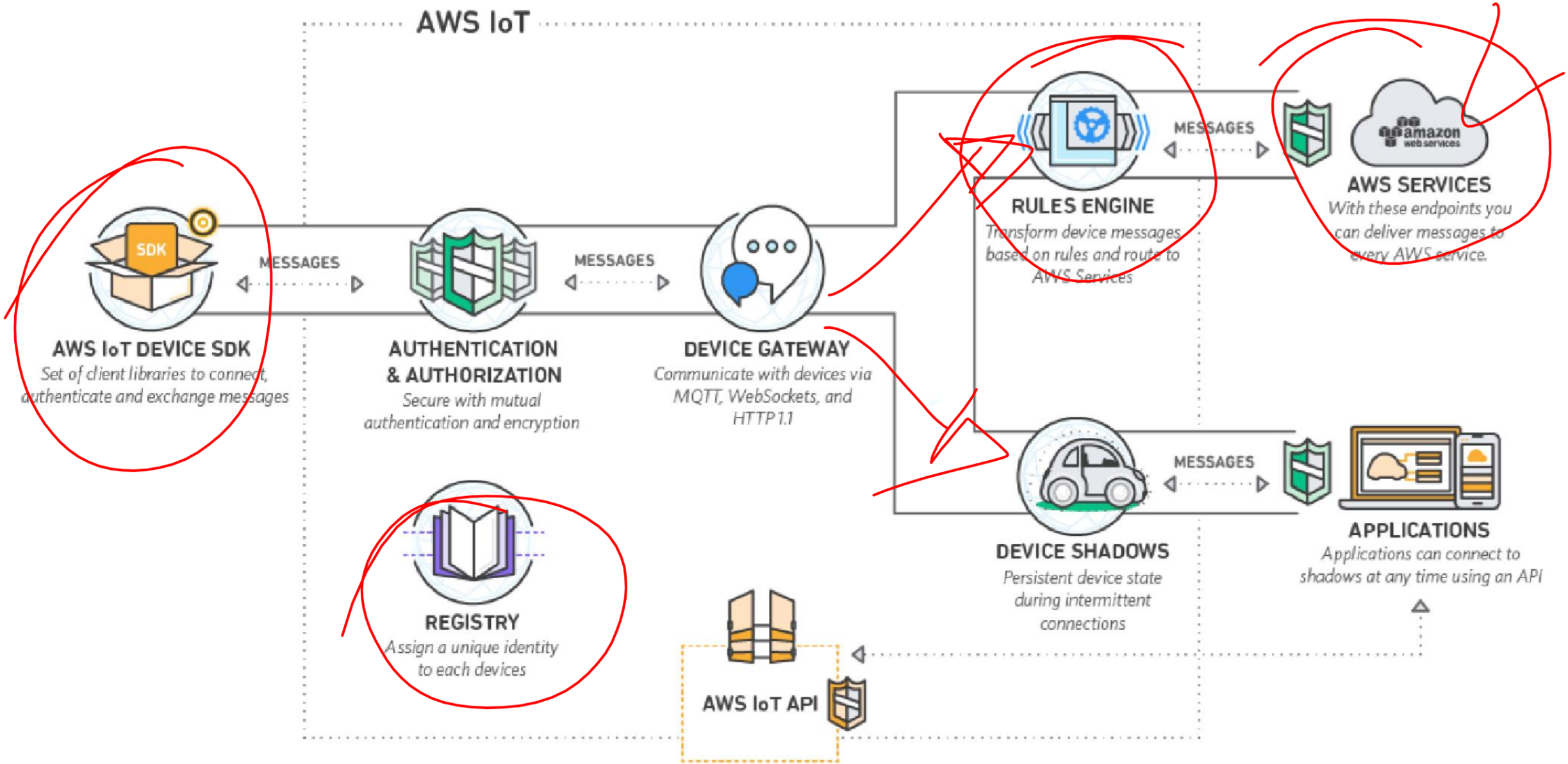
	Azure IoT	AWS	Google IoT
Edge			
Storage	Blob, CosmosDB, SQL		
Big Data			
Data Visualization	Power Bi		
Artificial Intelligence			
Intelligence API	Language, Speech, Vision, Knowledge		

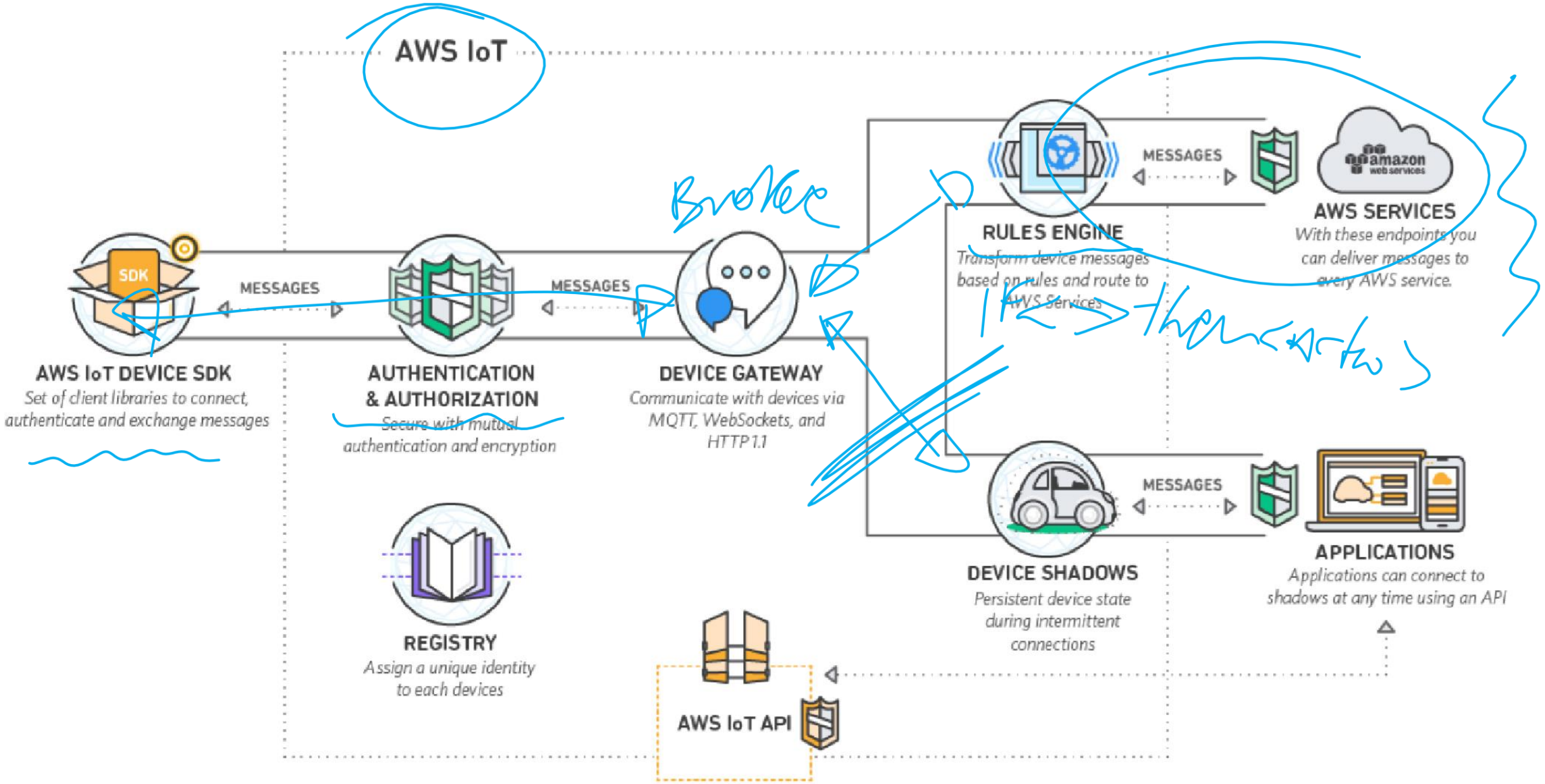
	Azure IoT	AWS	Google IoT
Protocolli	MQTT, AMQP, MQTT on WebSocket, HTTPS, AMQP on WebSocket	MQTT, MQTT on WebSocket, HTTPS	MQTT, HTTP
Communication Patterns	Telemetry, Query, Notification, Command	Telemetry, Query, Notification, Command	Telemetry, Query, Notification, Command

	Azure IoT	AWS	Google IoT
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
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%

	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


AWS IoT
SDK
MESSAGES
MESSAGES
MESSAGES
MESSAGES
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 HTTP 1.1
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.
amazon web services
REGISTRY
Assign a unique identity to each devices
DEVICE SHADOWS
Persistent device state during intermittent connections
APPLICATIONS
Applications can connect to shadows at any time using an API
AWS IoT API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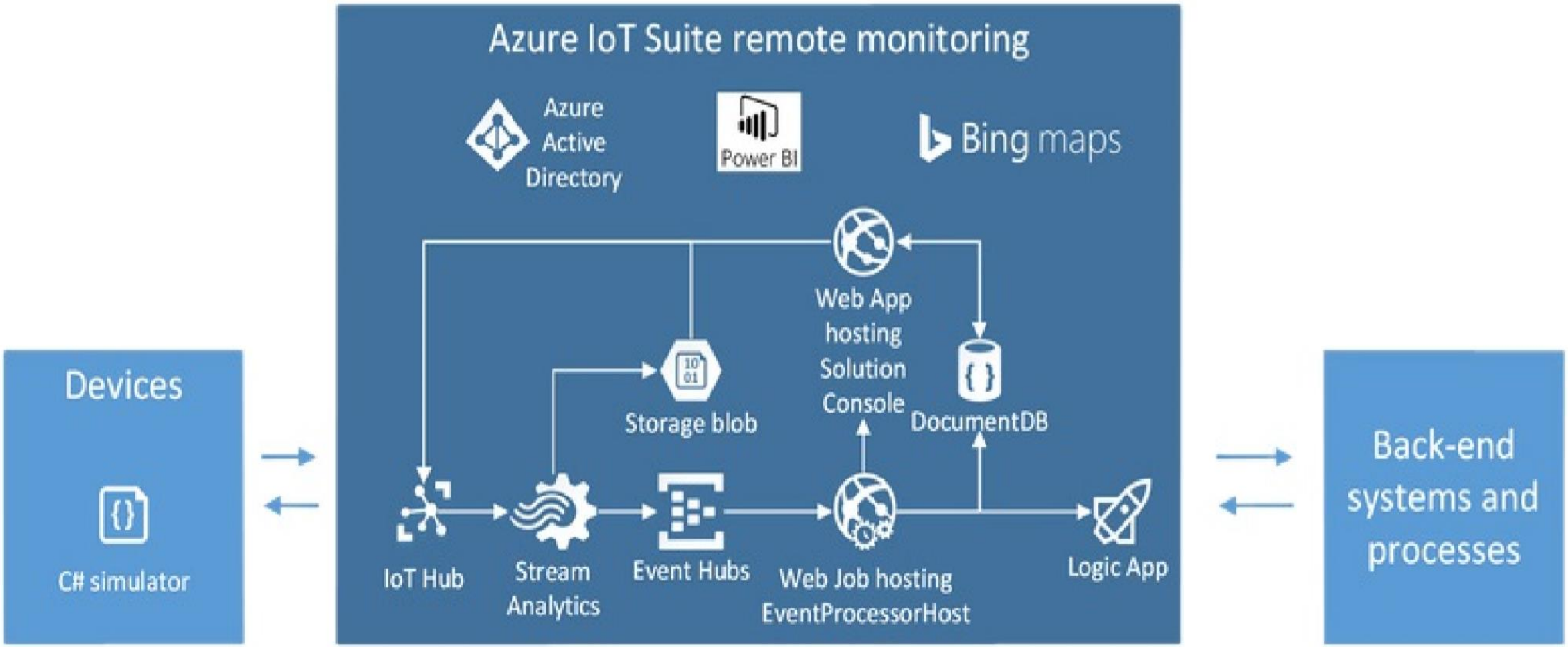
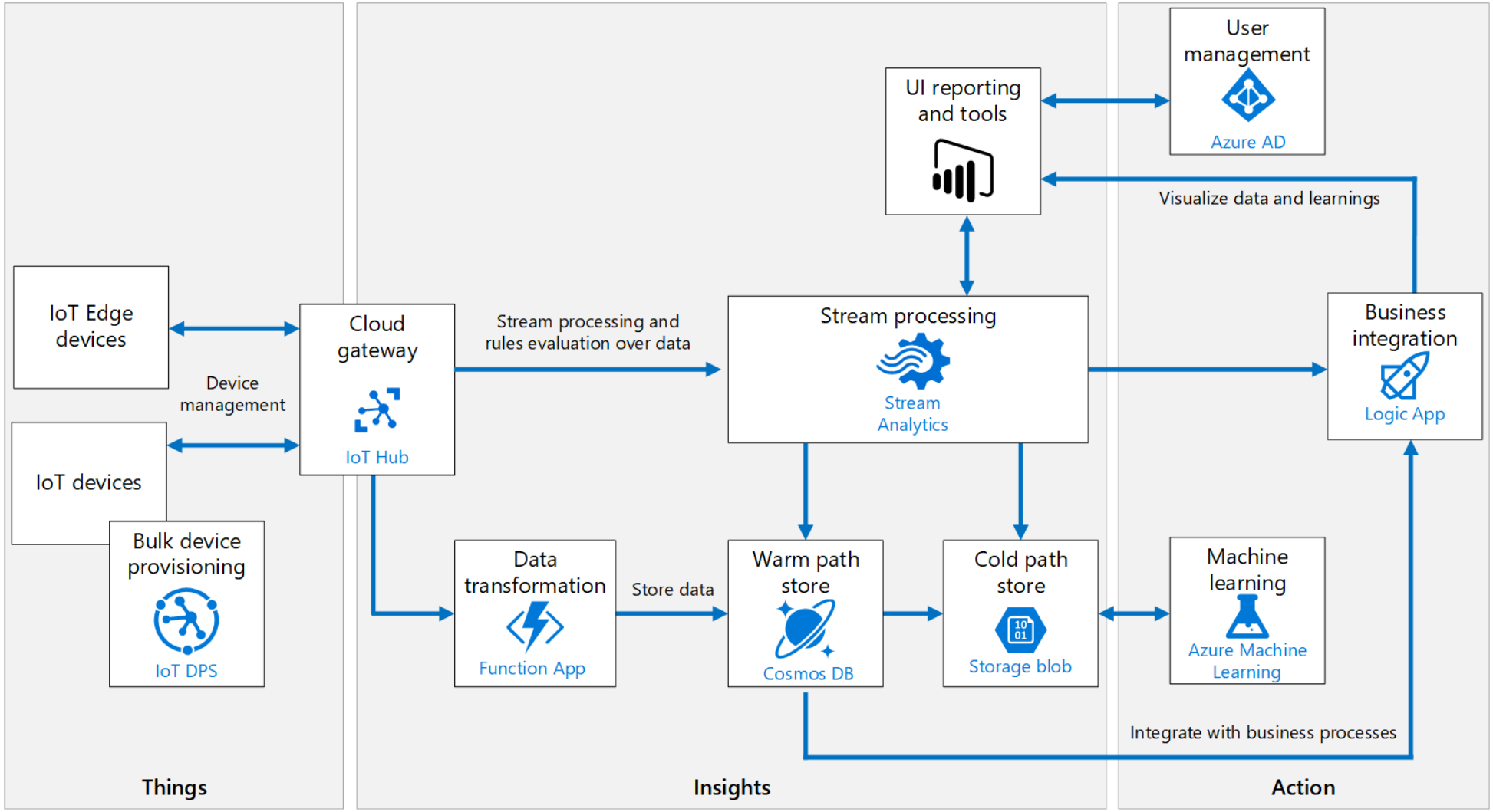
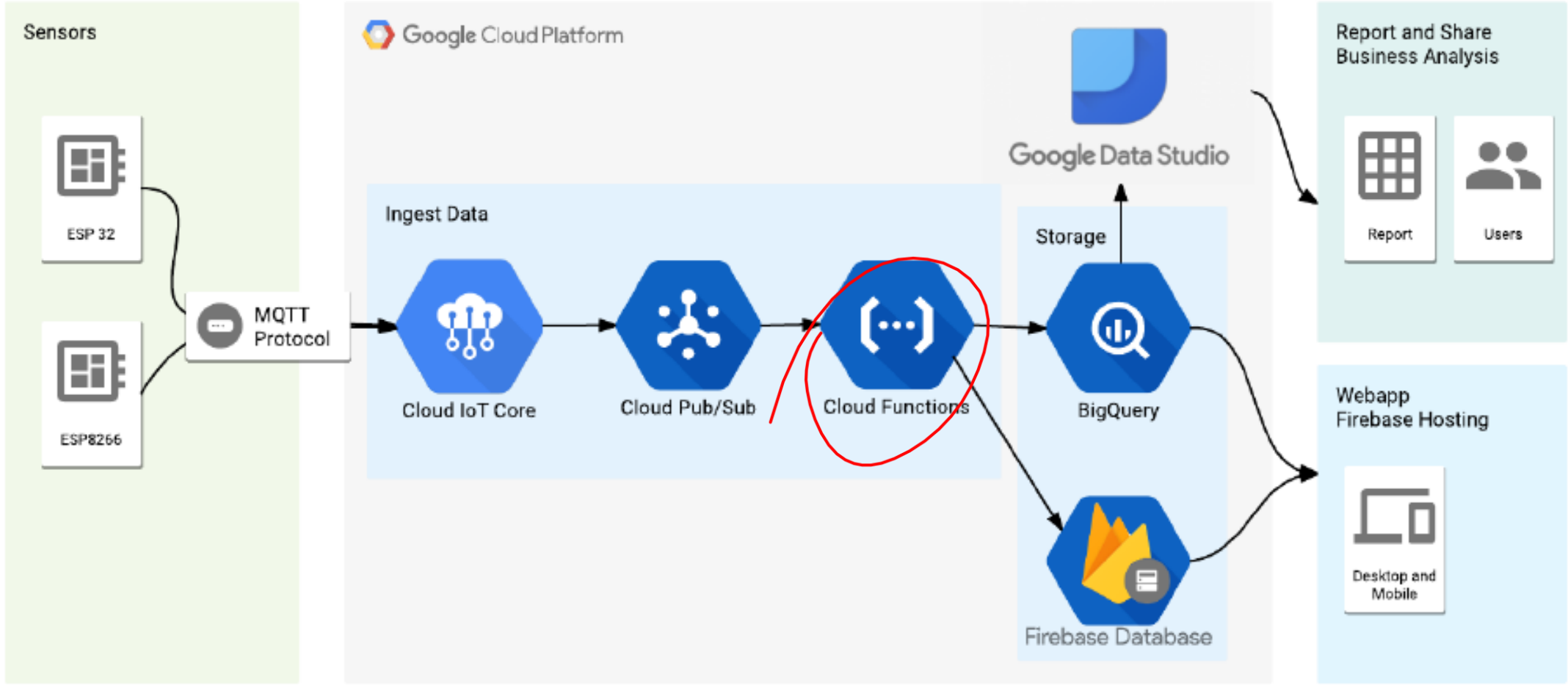

Azure IoT Suite remote monitoring
Azure Active Directory
Power BI
Bing maps
Web App hosting Solution Console
Storage blob
DocumentDB
Devices
C# simulator
IoT Hub
Stream Analytics
Event Hubs
Web Job hosting EventProcessorHost
Logic App
Back-end systems and processes

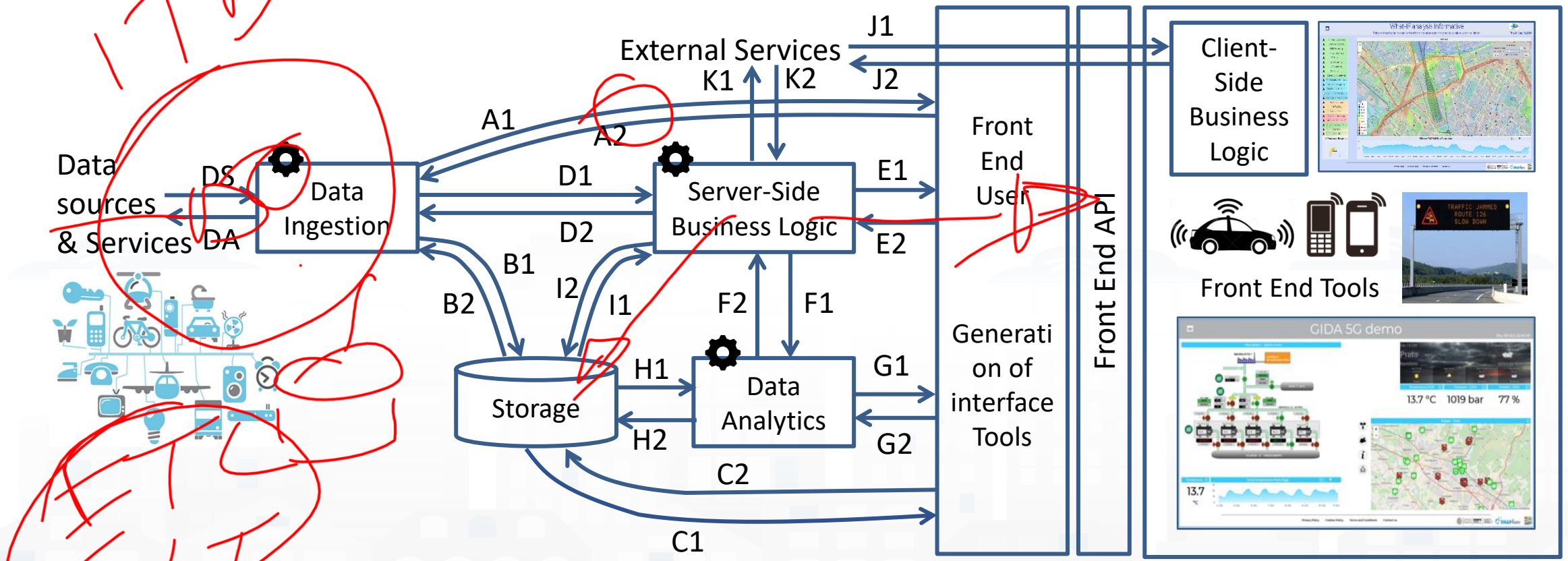
Azure Microsoft IoT (1)



Google IoT (1)


Sensors
ESP 32
ESP8266
MQTT Protocol
Google Cloud Platform
Ingest Data
Cloud IoT Core
Cloud Pub/Sub
Cloud Functions
Storage
Google Data Studio
BigQuery
Firebase Database
Report and Share Business Analysis
Report
Users
Webapp Firebase Hosting
Desktop and Mobile

Data Pipelines on AWS, Azure and GCP
aws
Ingestion
AWS IoT
Lambda Function
Kinesis Streams / Firehouse
Data Lake
Glacier
S3
Preparation & Computation
EMR
Glue ETL
Sage Maker
Kinesis Analytics
Data Warehouse
Glue Catalog
Elastic Search
Kinesis Streams
DynamoDB
RDS
RedShift
Presentation
Lambda Function
QuickSight
Athena (EDA)
Azure
Ingestion
Event Hub
Azure Function
Azure IoT Hub
Data Lake
Azure Data Lake Store
Preparation & Computation
Databricks
Data Explorer
Azure ML
Stream Analytics
Data Warehouse
Event Hub
Data Catalog
Azure SQL
Azure Redis Cache
Cosmos DB
Presentation
Azure Function
Power BI
Azure ML Designer/ Studio (EDA)
Google Cloud
Ingestion
PubSub
Cloud Function
Cloud IoT
Data Lake
Cloud Storage
Preparation & Computation
DataPrep
DataFlow
DataProc
AutoML
Data Warehouse
Data Catalog
BigQuery
Bigtable
PubSub
Memory store
Cloud SQL
Cloud Datastore
Presentation
Cloud Function
Datalab
Data Studio
Colab (EDA)
Piyush Ranjan


Data sources & Services
DS
DA
Data Ingestion
A1
A2
External Services
J1
J2
K1
K2
D1
D2
Server-Side Business Logic
E1
E2
B1
B2
I2
I1
F2
F1
Storage
H1
H2
Data Analytics
G1
G2
C2
C1
Front End User
Generation of interface Tools
Front End API
Client-Side Business Logic
Front End Tools
GIDA 5G demo

Requirements and Objectives

- Serve as a **City Dashboard**, **App User Interface**, etc.
  - Real time and historical data, any device, sensors and actuators
  - Sensors, KPI, maps, data trends, real time data, charts, etc.
  - Multi domain, smart city + industry 4.0 scenarious
- Referral / **historical data, and Open Data**:
  - shadow, access (API, storage, any protocol), production of OD, export
- **Data Driven Real Time communication &** processing:
  - IOT Applications, IOT edge, multiple operating systems, embedded systems, **MicroServices**
  - in/out data driven from/to the field into: applications, notifications, etc.
- **Data Analytics**: Machine Learning, statistics, reasoning, …
- **Serve as Living Lab**: open innovation, co-working; collaborative work; sharing: data, processes, dashboard, experiences, solutions, ….
- Experimented on **large scale cases**

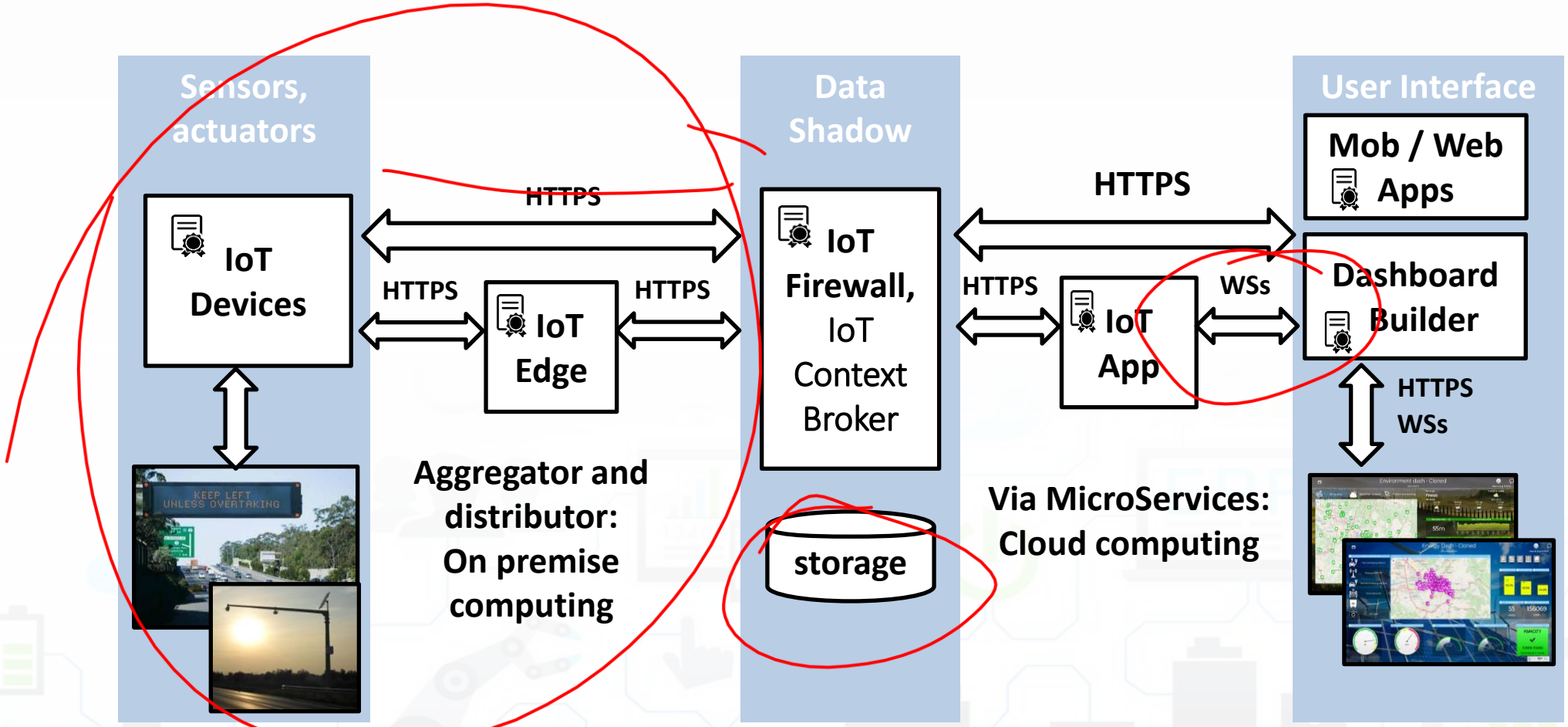
Non functional requirements

- **Open Source** based 100%
  - Open **Standard** for communication and API for In/Out
- **Interoperability**: protocols, internal API, Smart City API, ca , integrate with legacy conditions in place, modular, reusable,…
  - Open to proprietary protocols as well, any protocol, any format
- **Data driven**, for reading and data analytic
- **Scalable, Robust, Distributed** and Decoupled, modular, Service Oriented, open to external services and data sets, big data
- **Heterogeneous**: any device, private and public, custom and..
- **Security** by Design: HTTPS, TLS, … compliant with EC
- **User Centric** Design: privacy by Design (and **GDPR**), personalized, personal data management, ...

Security/Privacy Requirements

- **Managing** private data together with public data
- **Private data management** according to GDPR
  - Browsing, downloading, controlling rights, delegating access, revoking accesses, etc.
  - Keep them safe
- Secure enough to delegate management of data regarding public security:
  - Data that could be used against us by some terrorist, or anyway by someone with some bad intention, for example to access in our home when we are far away, etc.

The secure stack

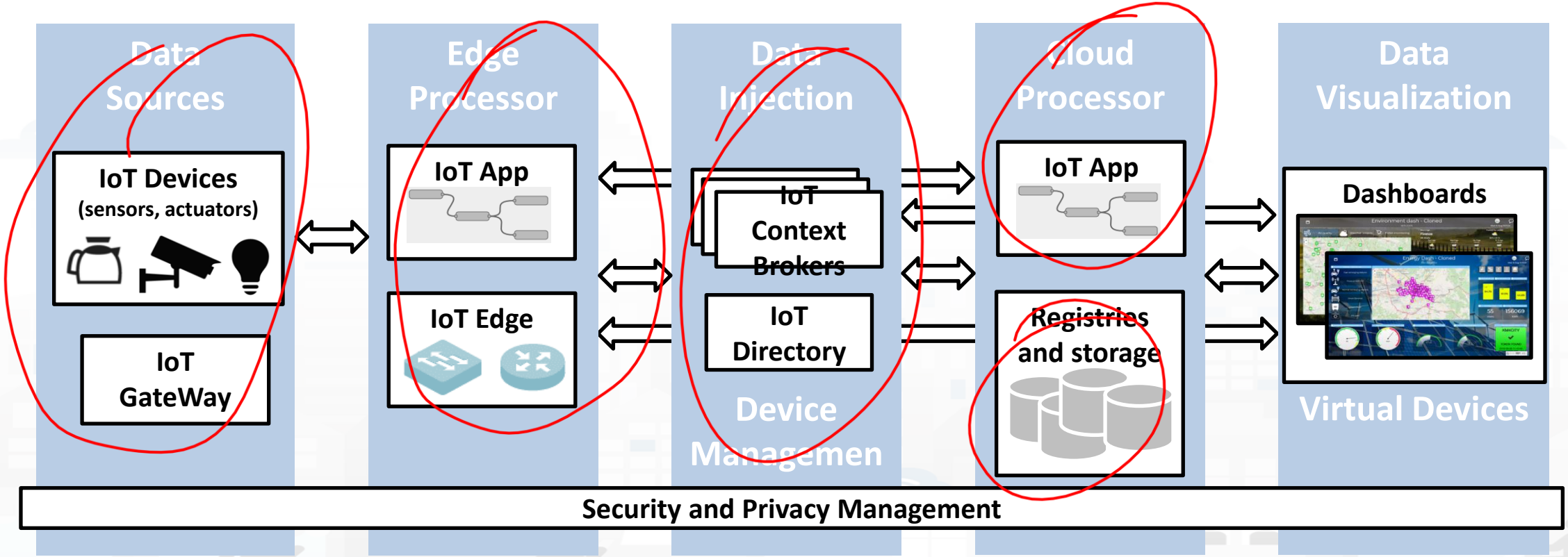


Complexity in Smart City IOT Platforms

End to End security

– From IOT Devices to Dashboard (user interface)

- H2M
- M2M



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DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

https://www.disit.org/
Paolo Nesi, paolo.nesi@unifi.it

Snap4City Architectures

https://www.snap4City.org **https://www.Km4City.org**

Parte: 4b (2024)

Digital Twin Solutions for Sustainability

100% OPEN SOURCE

Powered by FIWARE

FREE TRIAL

PEN Test Passed

EU GDPR COMPLIANT

SNAP4 Appliances and Dockers Installations

EUROPEAN OPEN SCIENCE CLOUD

Node-RED

JS Foundation

E015 digital ecosystem

NVIDIA

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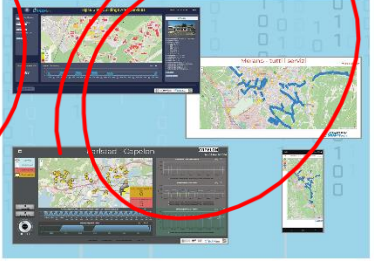
OPERATION AND PLAN - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - OPTIMIZATION - APPLICATIONS

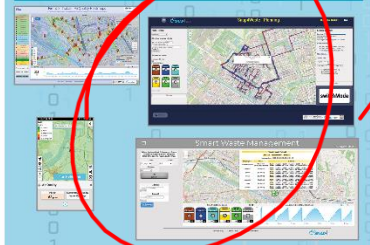
CONTROL AND PLAN

MOBILITY AND TRANSPORT

SMART ENERGY AND SMART BUILDING



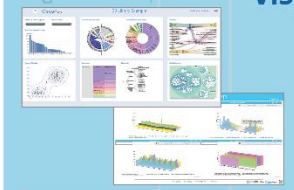
ENVIRONMENT AND WASTE MANAGEMENT



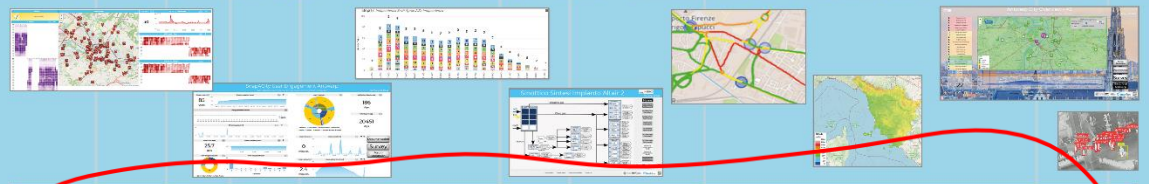
CITY USER'S SERVICES AND TOURISM MANAGEMENT

- DEVELOMENT ENVIRONMENT AND METHODOLOGY
- VISUAL PROGRAMMING, ML, AI, HPC TRAINING COURSES
- LIVING LABS
- GUI CUSTOM STYLES
- FULL APPLICATIONS, DASHBOARDS AND VIEWS
- MOBILE APPS

VISUAL ANALYTICS - SYNOPTICS - GRAPHICAL WIDGETS - ANALYTICS - BUSINESS INTELLIGENCE - SIMULATIONS



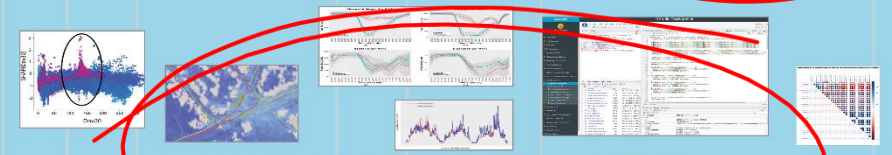
DASHBOARDS, WIDGETS TEMPLATES



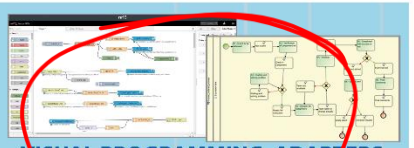
PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW - PEOPLE FLOWS - SDG
15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - ETC...

API - MICROSERVICES - GIS - BPM
VIDEO - REPORTS - MAPS - 3D ...

EXPERT SYSTEM, KNOWLEDGE BASE
SEMANTIC REASONING
SMART DATA MODEL
IOT DEVICE MODELS, STORAGE

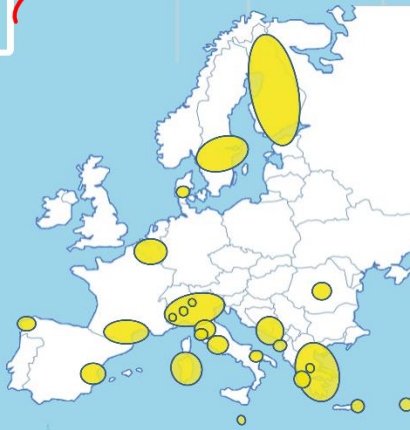


BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE
EXPLAINABLE AI, MACHINE LEARNING, GENERATIVE AI
OPERATIVE RESEARCH, STATISTICS



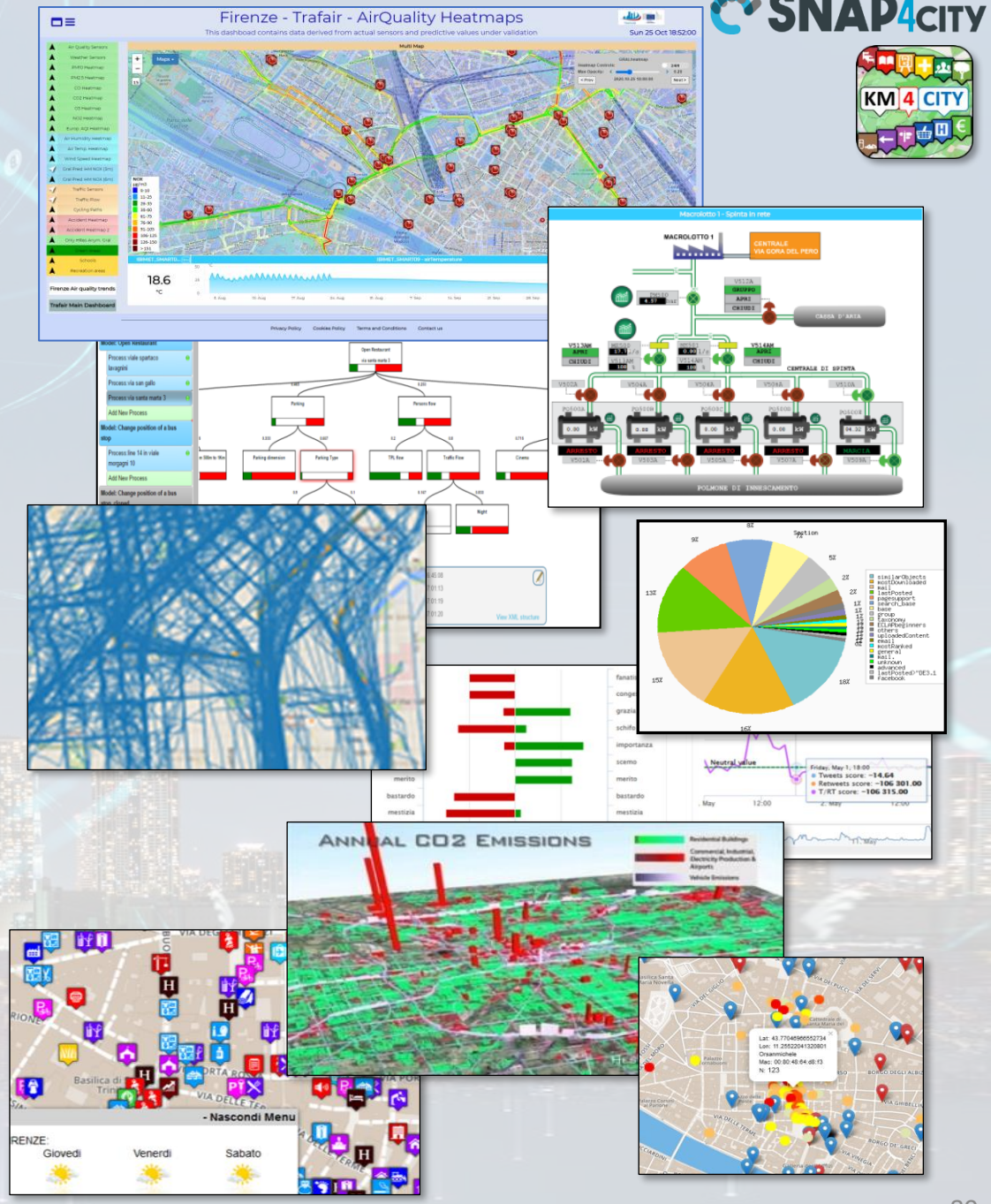
VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
PARALLEL DISTRIBUTED PROCESSING
DATA DRIVEN

FULL INTEROPERABILITY, ANY: DATA, BROKERS, NETWORKS AND VERTICALS

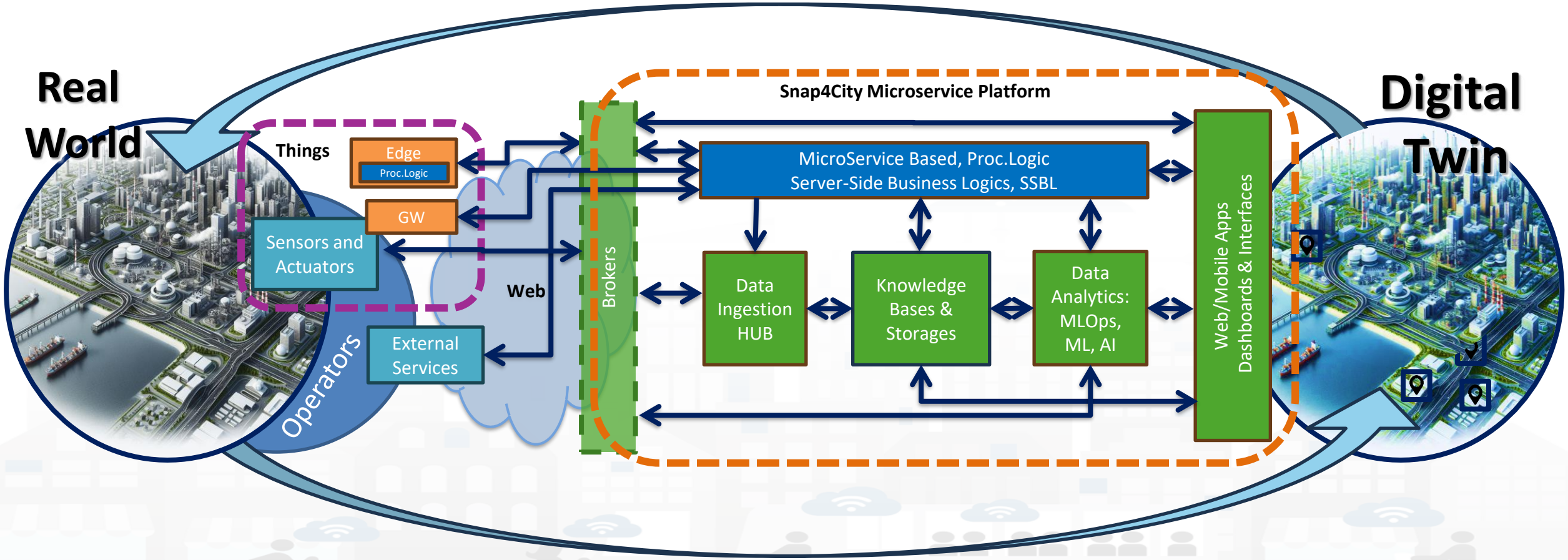


Data Driven Decision Support

- Decision Support system
- Assessment / Strategies
- Data Rendering, visual analytics
- Data Processing
- Data aggregation, Storage, indexing
- Data Ingestion

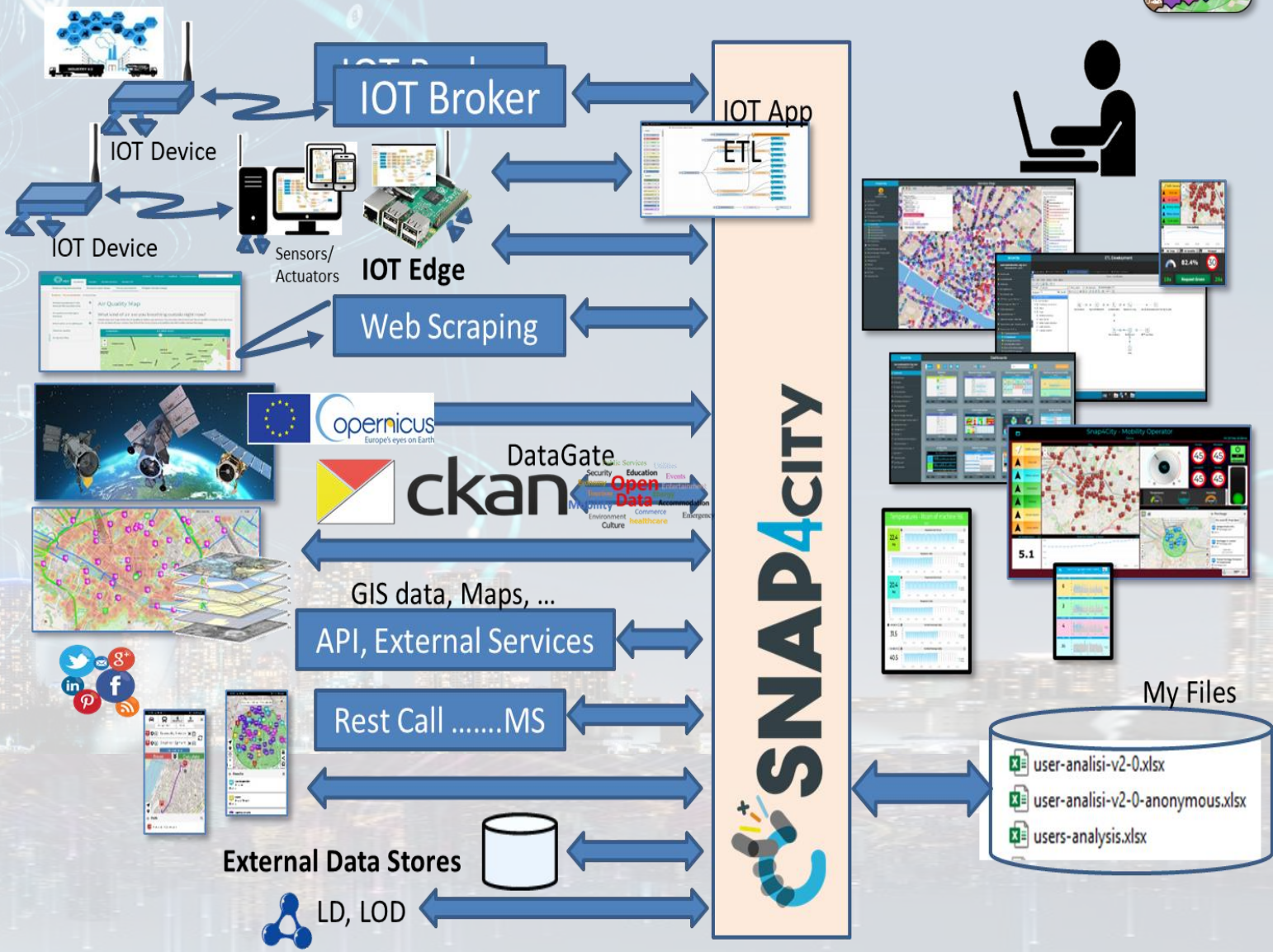


Digital Twin Development Platform



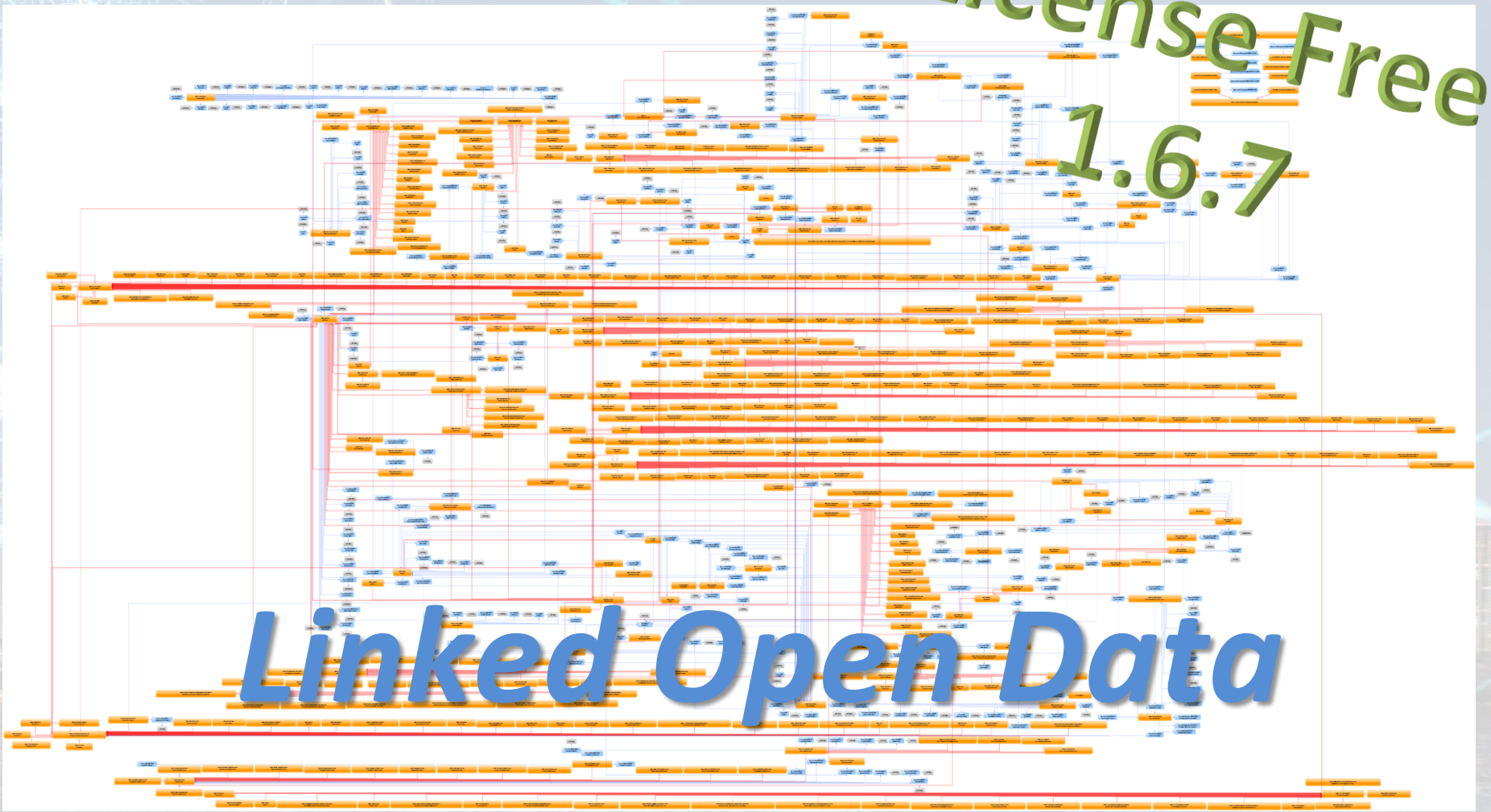
Ingestion, agg. → exploitation

- **Snap4City efficient tools for**
  - Bidirectional data channels
  - Any format, any channel, any data, any broker, any protocol, …
  - **Km4City** Knowledge base Ontology reasoning on geo, space, time, relationships



Expert System semantic queries

- **via**:
- **Smart City API** for Apps and third party
- **MicroServices** data driven develop via visual language Node-RED

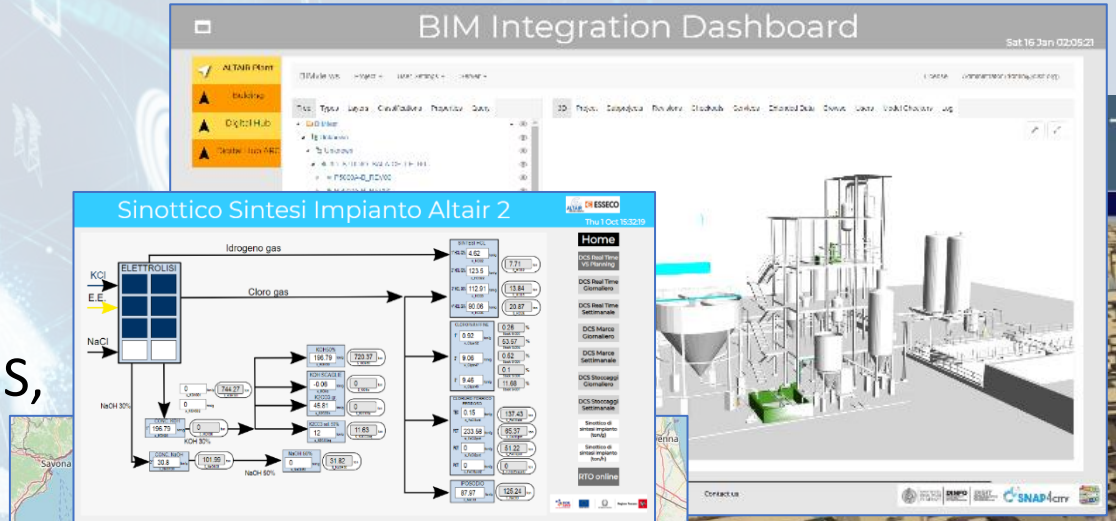


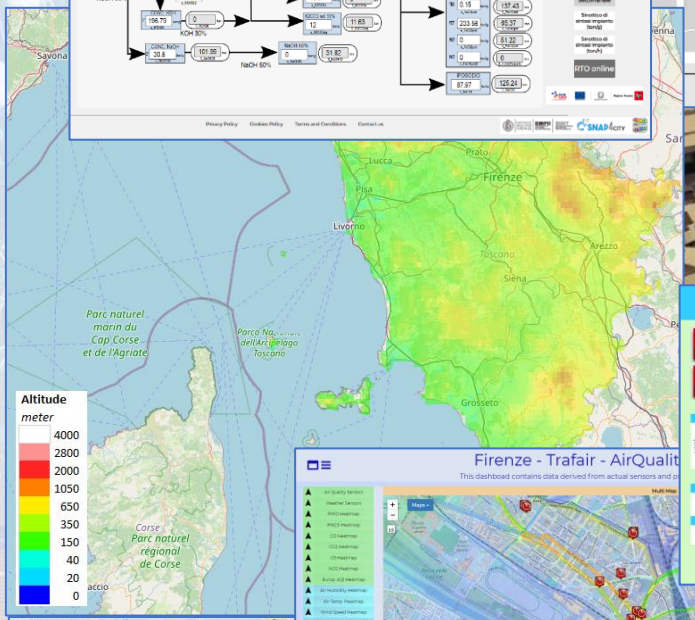
https://www.snap4city.org/19

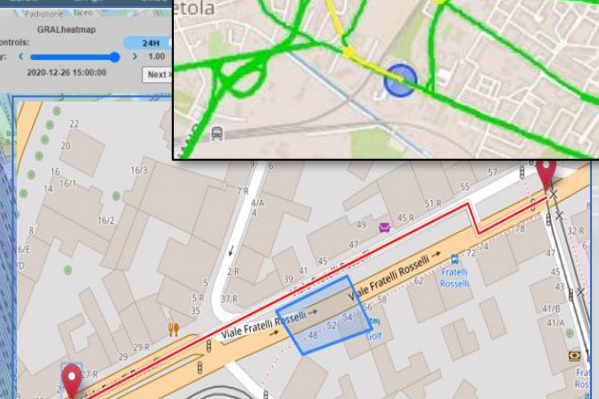
High Level Types

Snap4City (C), October 2024

- POI, IOT Devices, shapes,..
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, ..
- traffic flow, typical trends, ..
- trajectories, events, Workflow, ..
- 3D Models, BIM, Digital Twins, ..
- OD Matrices of several kinds, ..
- Dynamic icons/pins, ..
- Synoptics, animations, ..
- KPI, personal KPI,..
- social media data, TV Stream,
- routing, multimodal, constraints, ..
- decision scenarios, ….
- etc.

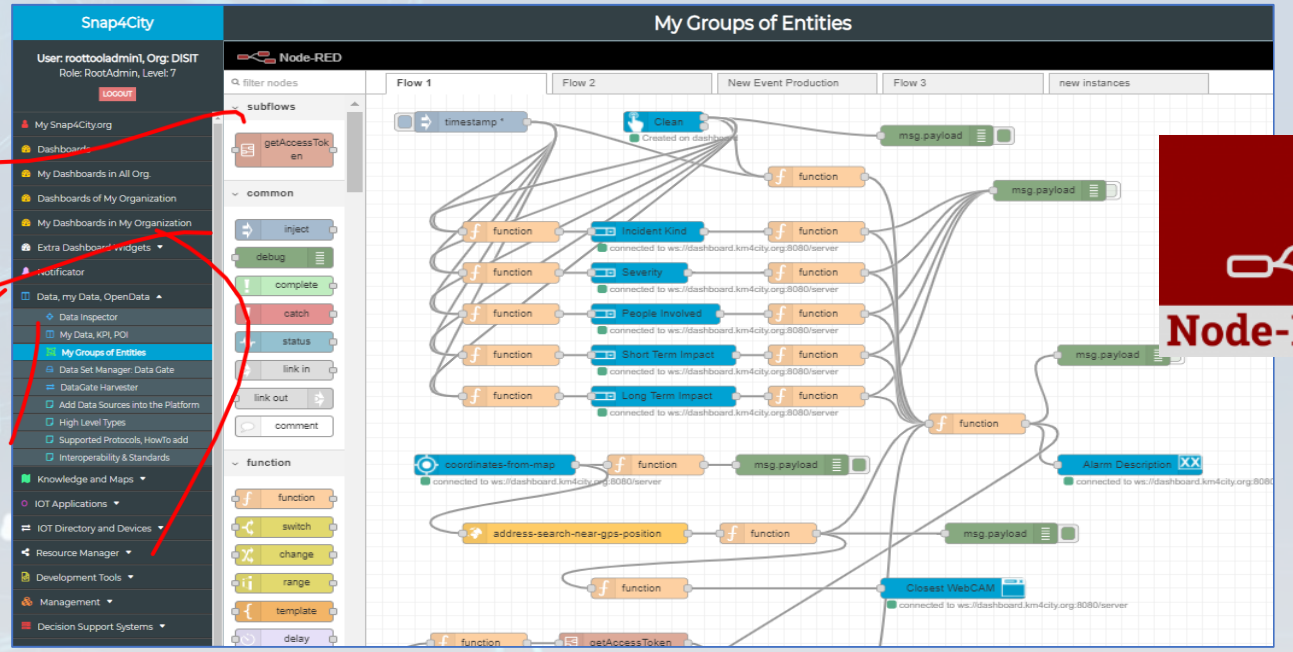


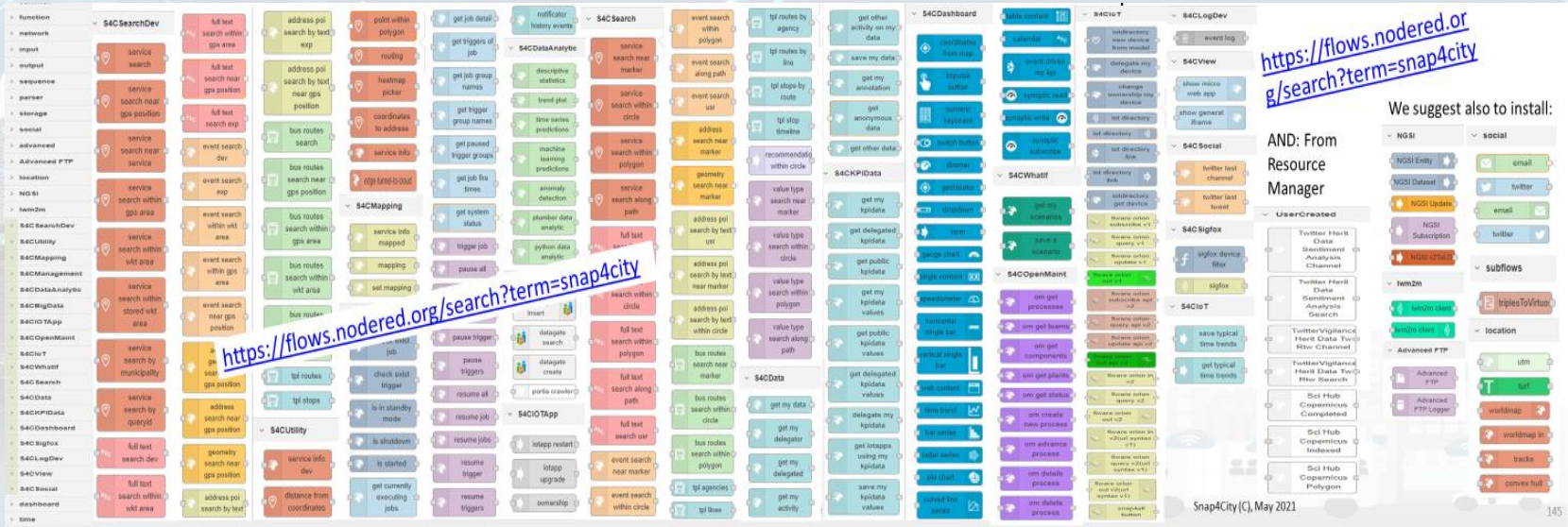




Ingestion, aggreg. → exploitation

- **IoT App Visual Programming, no coding**
  - **Data transformation**
  - **Integration**
  - **Scripting Data Analytics**
  - **Data ingestion**
  - **Business logic**
- **MicroServices** data driven develop via visual language Node-RED

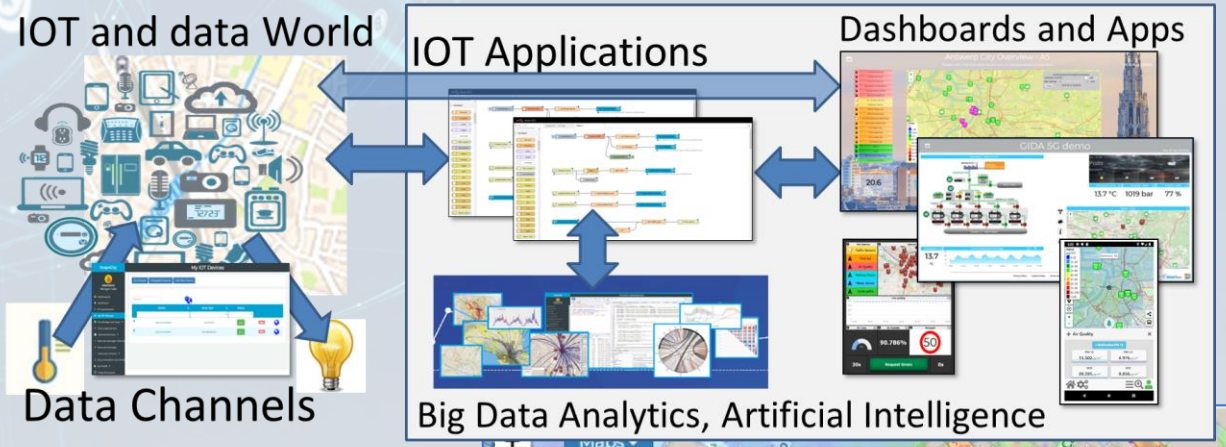


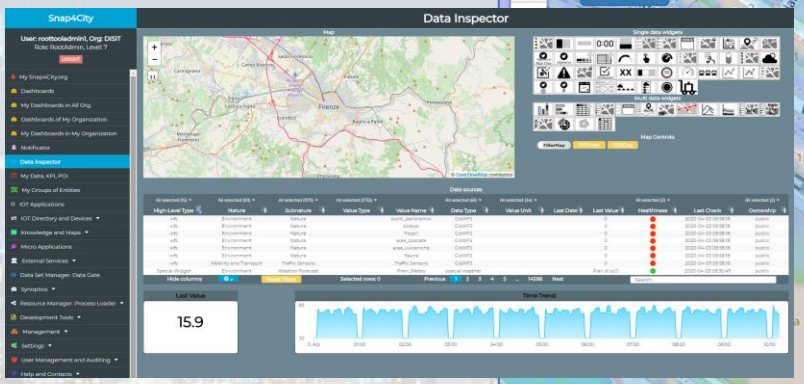


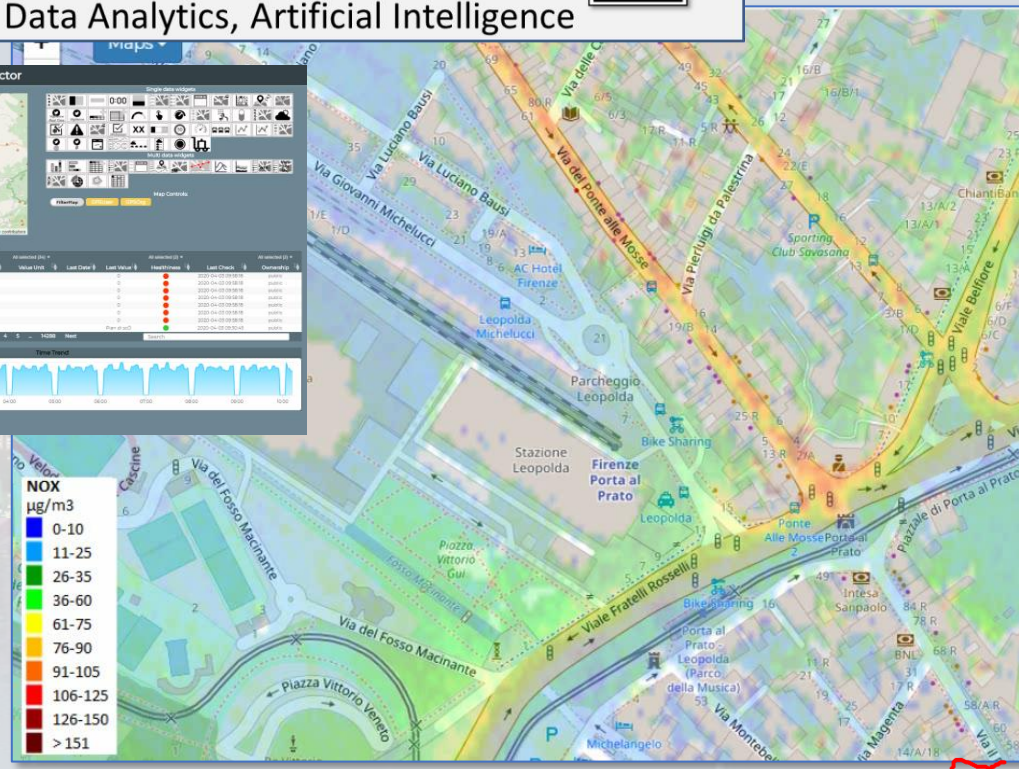
Solutions: reliable, secure and fast to realize

- **Via Snap4City tools**
  - **Dashboard Wizard**
  - **Dashboard Builder**
  - **Data/Visual Analytic**

- **Smart Solutions results to be**
  - **Real time data drive**
  - **Secure end-to-end**
  - **GDPR compliant**
  - **Reliable, interoperable**
  - **Auditable, marketable**

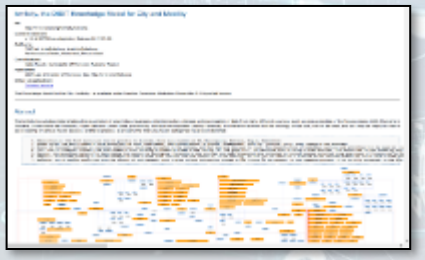






Data Analytics on Snap4City platform

Swagger



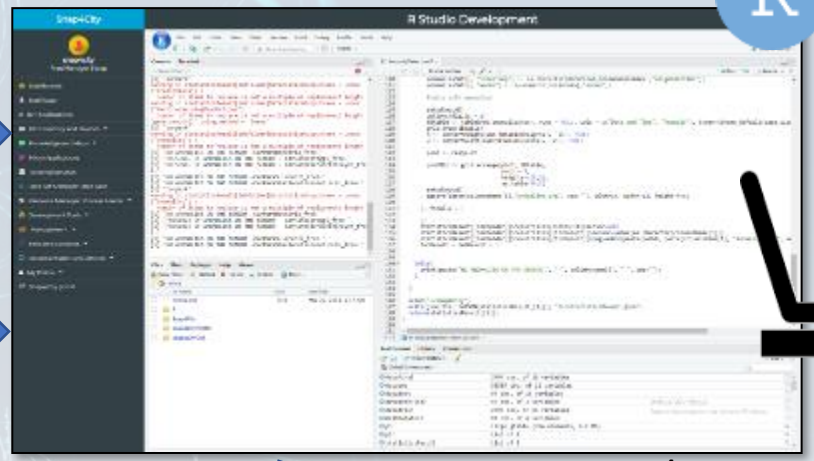
Ontology Schema

LOG.disit.org

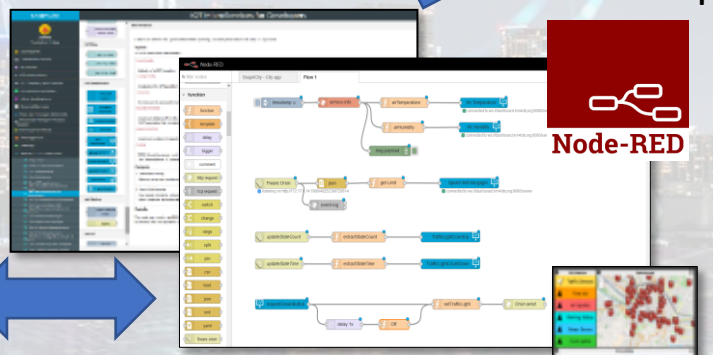
Knowledge Base, Km4City

Big Data Store Facility

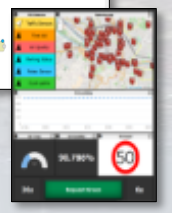
Smart City API from Knowledge Base and other tools



Creating MicroServices



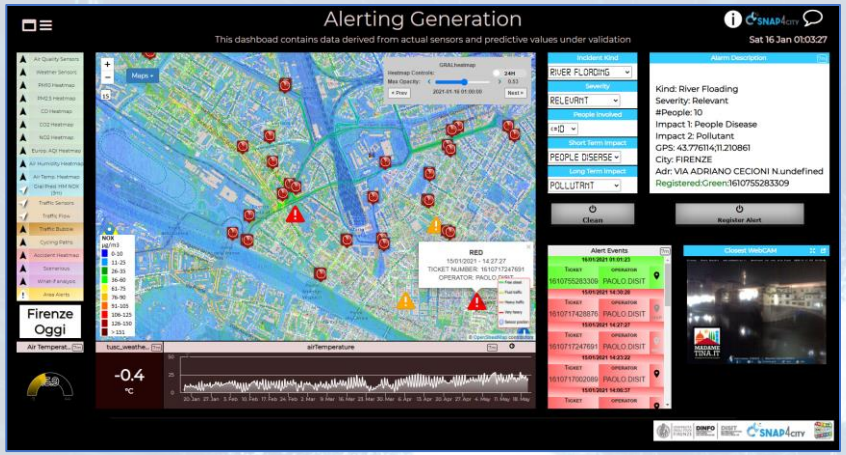
Node-RED

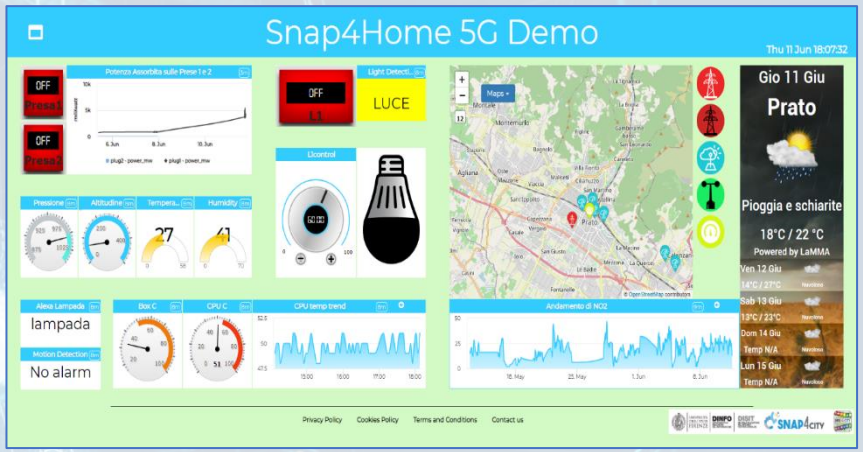


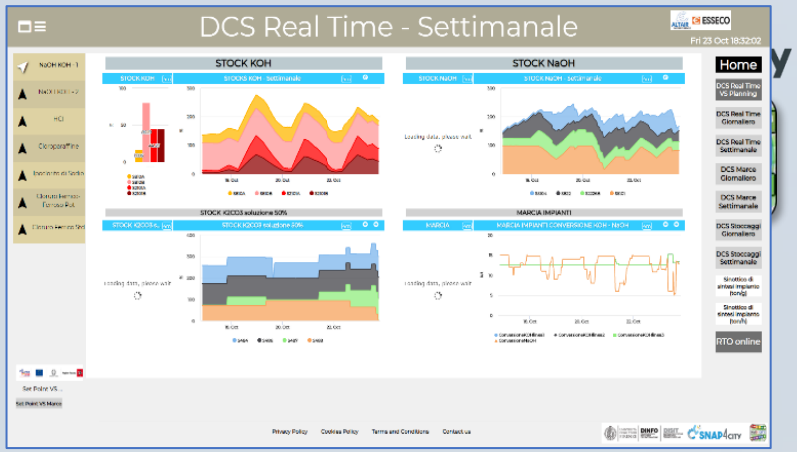
Using them into IOT Applications

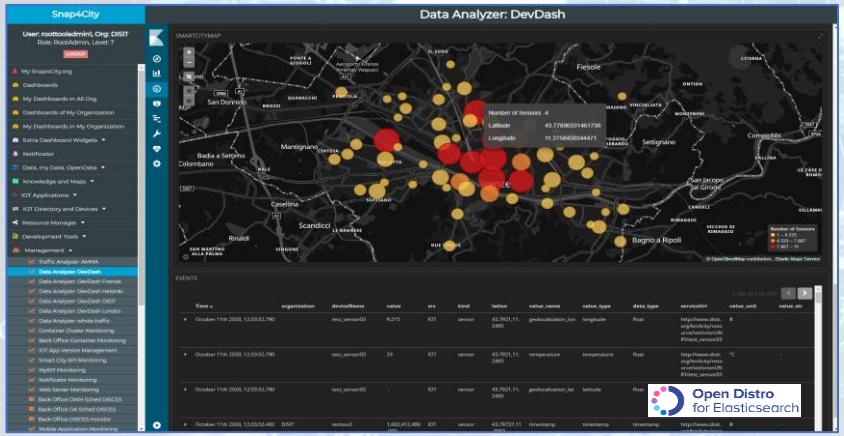
Saving / Sharing reusing

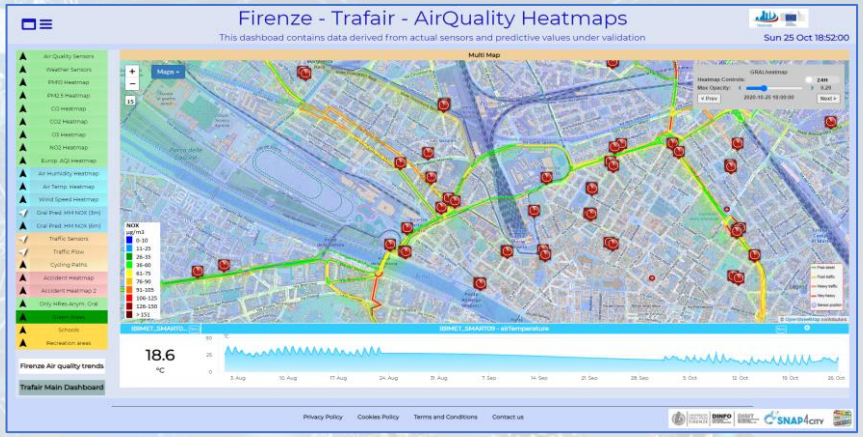
Resource Manager

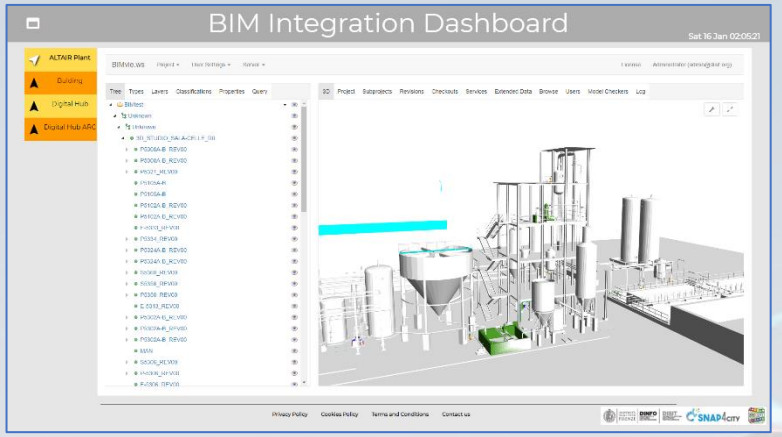

Alerting Generation
This dashboad contains data derived from actual sensors and predictive values under validation
Firenze Oggi
-0.4


Snap4Home 5G Demo
Gio 11 Giu
Prato
Pioggia e schiarite
18°C / 22 °C
lampada
No alarm

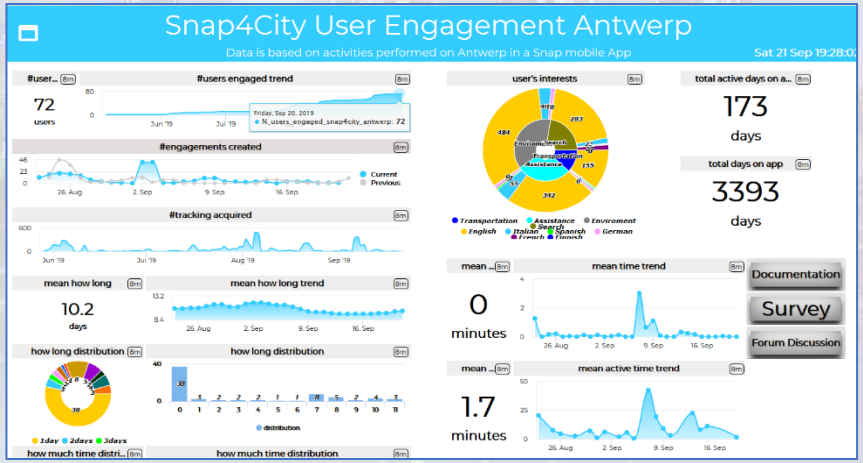

DCS Real Time - Settimanale
STOCK KOH
STOCK NaOH

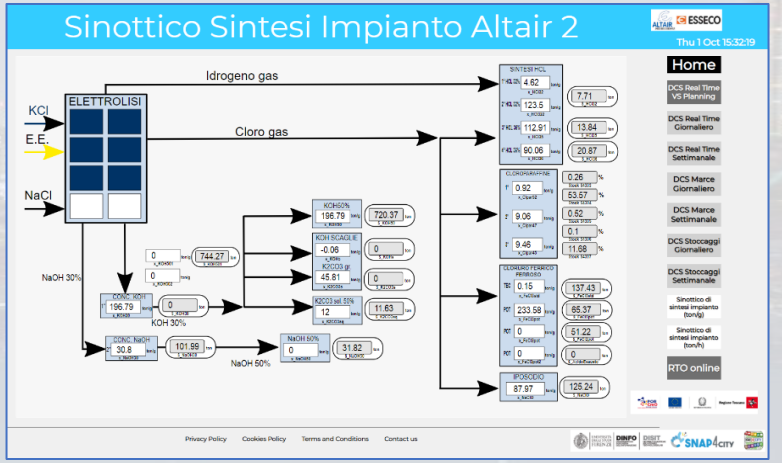

Data Analyzer: DevDash
Open Distro for Elasticsearch


Firenze - Trafair - AirQuality Heatmaps
This dashboad contains data derived from actual sensors and predictive values under validation
18.6

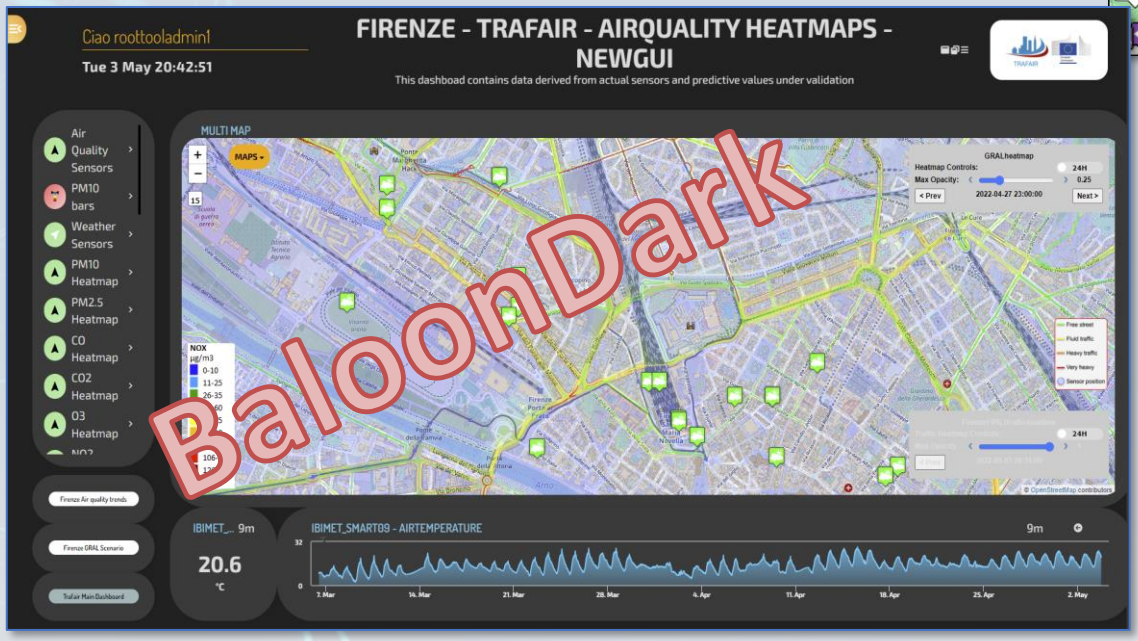

BIM Integration Dashboard

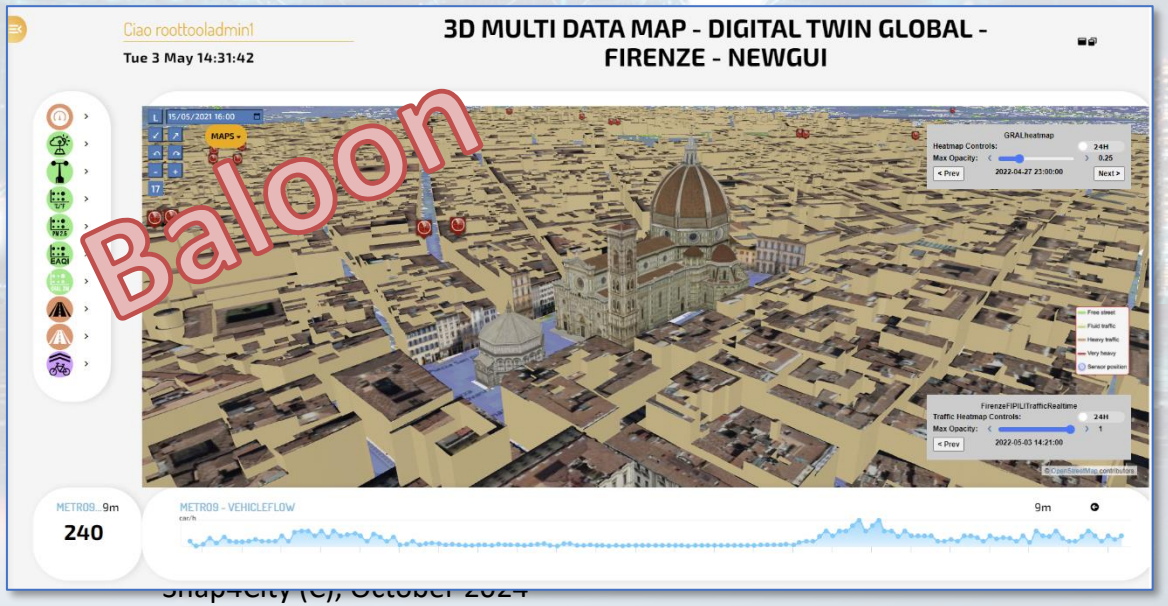

3D Multi Data Map - Digital Twin Global - Firenze
demonstrator
192

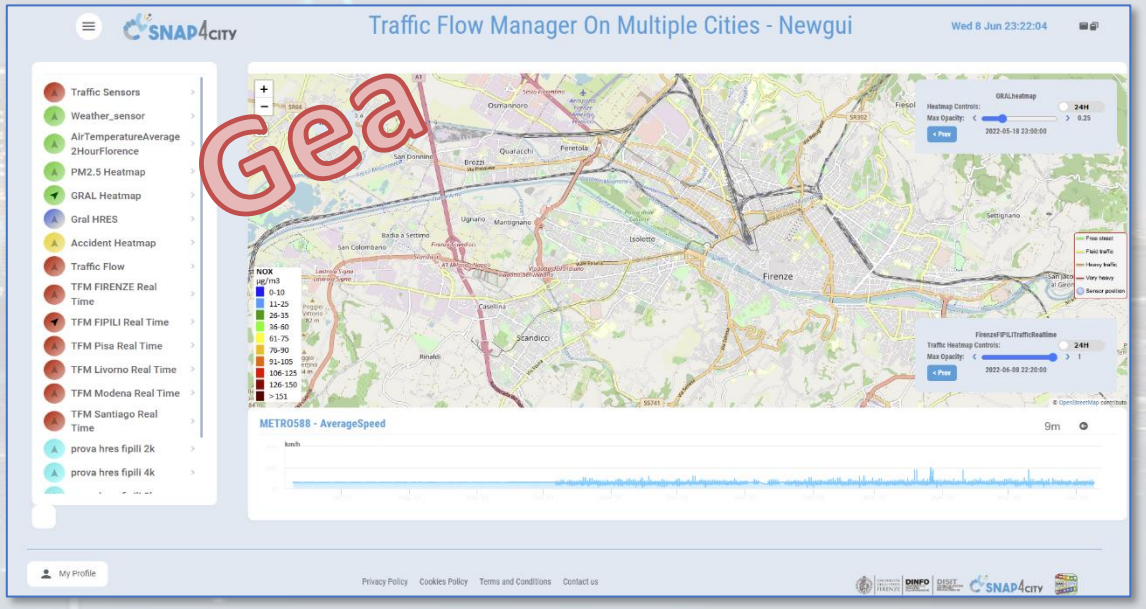

Snap4City User Engagement Antwerp
Data is based on activities performed on Antwerp in a Snap mobile App
72
users
173
days
3393
days
10.2
days
0
minutes
1.7
minutes
Documentation
Survey
Forum Discussion

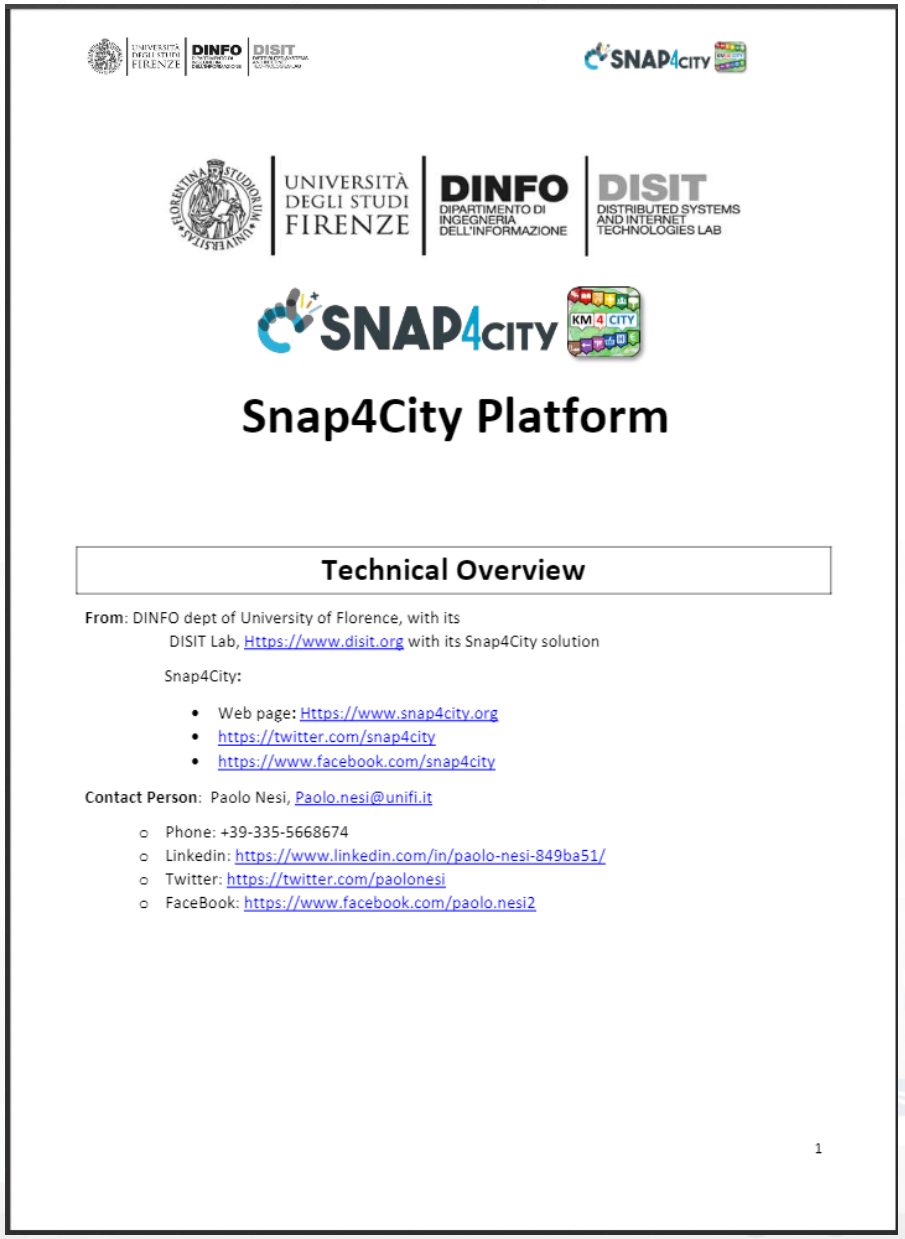

Sinottico Sintesi Impianto Altair 2
Idrogeno gas
Cloro gas
ELETTROLISI
KCl
E.E.
NaCl
NaOH 30%
KOH 30%
NaOH 50%

Different Themes









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

SNAP4CITY KM4CITY

Snap4City Platform

Technical Overview

From: DINFO dept of University of Florence, with its
DISIT Lab, Https://www.disit.org with its Snap4City solution

Snap4City:

- Web page: Https://www.snap4city.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city

Contact Person: Paolo Nesi, Paolo.nesi@unifi.it

- Phone: +39-335-5668674
- Linkedin: https://www.linkedin.com/in/paolo-nesi-849ba51/
- Twitter: https://twitter.com/paolonesi
- FaceBook: https://www.facebook.com/paolo.nesi2

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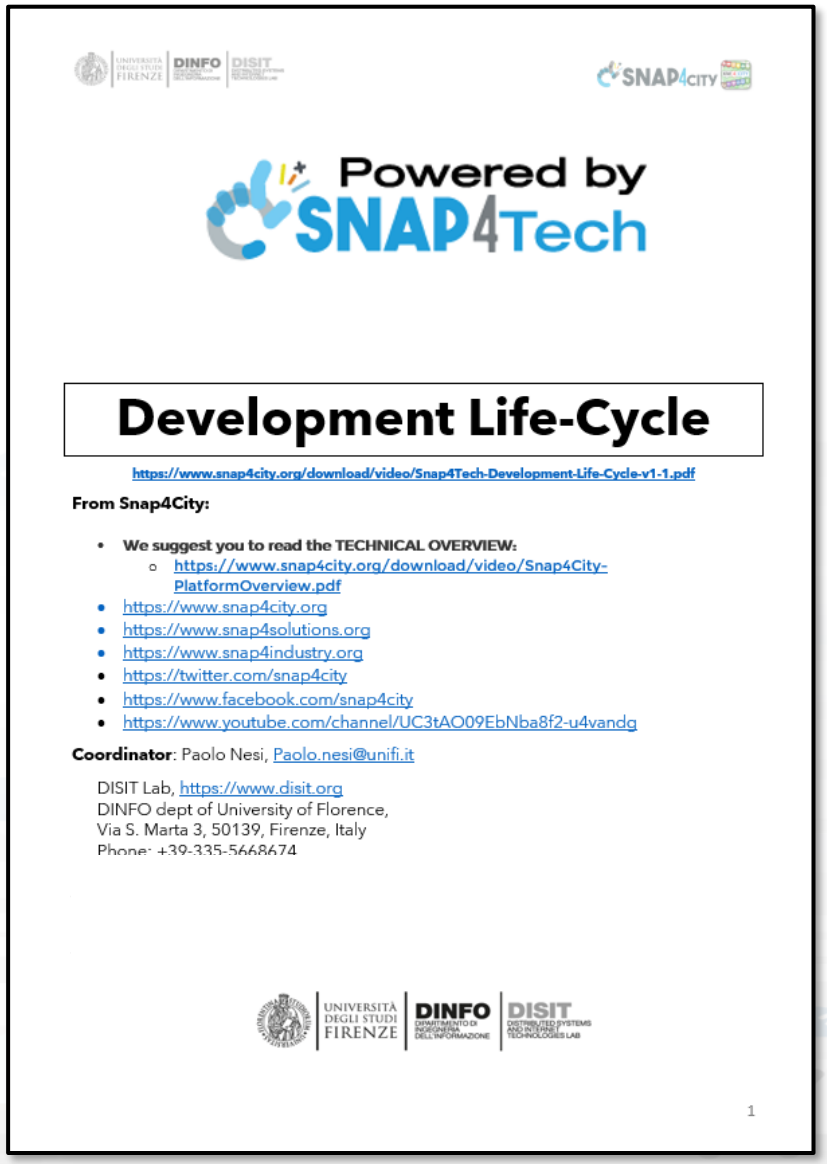
Tech Overview

- https://www.snap4city.org/drupal/sites/default/files/files/Snap4City-PlatformOverview.pdf

Development



Powered by SNAP4Tech

Development Life-Cycle

https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle-v1-1.pdf

From Snap4City:

- **We suggest you to read the TECHNICAL OVERVIEW:**
  - https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf
- https://www.snap4city.org
- https://www.snap4solutions.org
- https://www.snap4industry.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org
DINFO dept of University of Florence,
Via S. Marta 3, 50139, Firenze, Italy
Phone: +39-335-5668674

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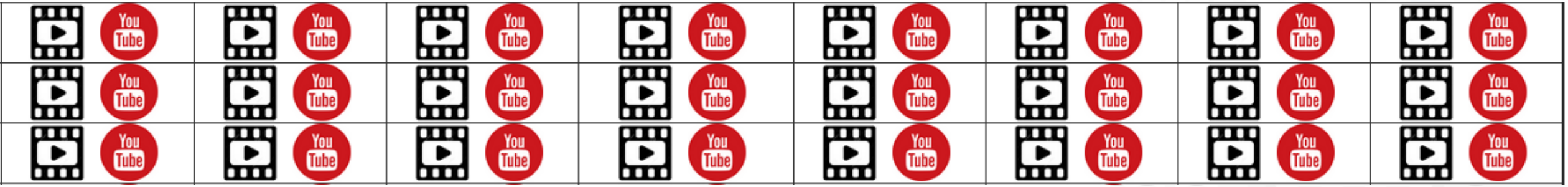
https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf

https://www.snap4city.org/944

On Line Training Material (free of charge)

1st part	2nd part	3rd part	4th part	5th part	6th part	7th part	8th
Overview	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App	Design and Develop Smart Solutions
							
							



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DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

https://www.disit.org/
Paolo Nesi, paolo.nesi@unifi.it

Interoperability

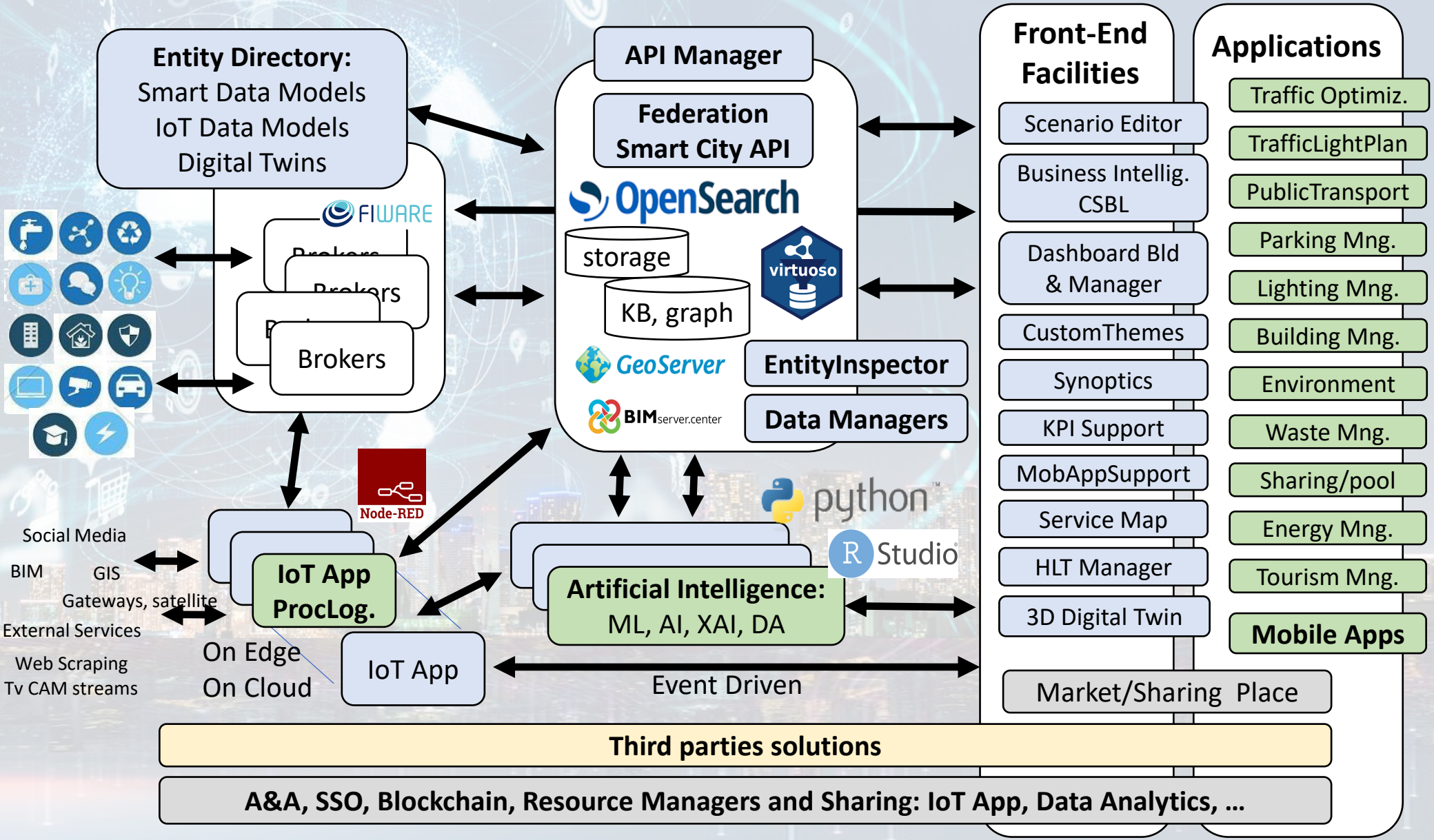
https://www.snap4City.org https://www.Km4City.org

Parte: 4b (2024)

TOP

From Time Series to complex types

Technical Architecture



Standards and Interoperability (10/2024)

Compliant with:

- **IoT:** NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, Enocean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- **IoT model:** FIWARE Smart Data Model, Snap4City IoT Device Models
- **General**: HTTP, HTTPS, TLS, Rest Call, SNMP, TCP, UDP, SOAP, WSDL, FTP, FTPS, WebSocket, WebSocket Secure, GML, WFS, WMS, RTSP, ONVIF, AXIS TVCam, CISCO Meraki, OSM, Copernicus, The Weather Channel, Open Weather, OLAP, VMS Milestone, TIM, HERE, ….
- **Formats**: JSON, GeoJSON, XML, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, XLS, XLSX, TXT, HTML, CSS, SVG, IFC, XPDL, OSM, Enfuser FMI, Lidar, glTF, GLB, DTM, GDAL, Satellite, D3 JSON, …
- **Database**: Open Search, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Elastic Search, Phoenix, PostGres, MS Azure, ..
- **Industry**: OPC/OPC-UA, OLAP, ModBUS, RS485, RS232,..
- **Mobility**: DATEX, GTFS, Transmodel, ETSI, NeTEx, ..
- **Social**:Twitter, FaceBook, Telegram, ..
- **Events**: SMS, EMAIL, CAP, RSS Feed, ..
- **OS**: Linux, Windows, Android, Raspberry Pi, Local File System, AXIS, ESP32, etc.

https://www.snap4city.org/65

IoT Devices

IoT Device Models

IoT Device
- Name:…..
- Model:…..
- Position: …….

IoT Device Variables
- **dateObserved: ……..**
- ID:
- Status: ready
- Temperature: 70%
- WaterLevel: 35%
- UsedCapsBox: 30%
- Power: OK
- …..

- Conceptually are IoT Devices with sensors/actuators, IN/IN-OUT
- They are classified in terms of nature/subnature
- For Searching and showing on maps and dashboards **HLT of IoT Devices** can be:
  - **IoT Device Models**, for example: «personal coffee machine»
  - **IoT Device** name, for example: «mycoffemachine1», «CM23»
  - **IoT Device Variable**, for example: «Temperature»

What About IoT Devices, Time Series

IOT Device

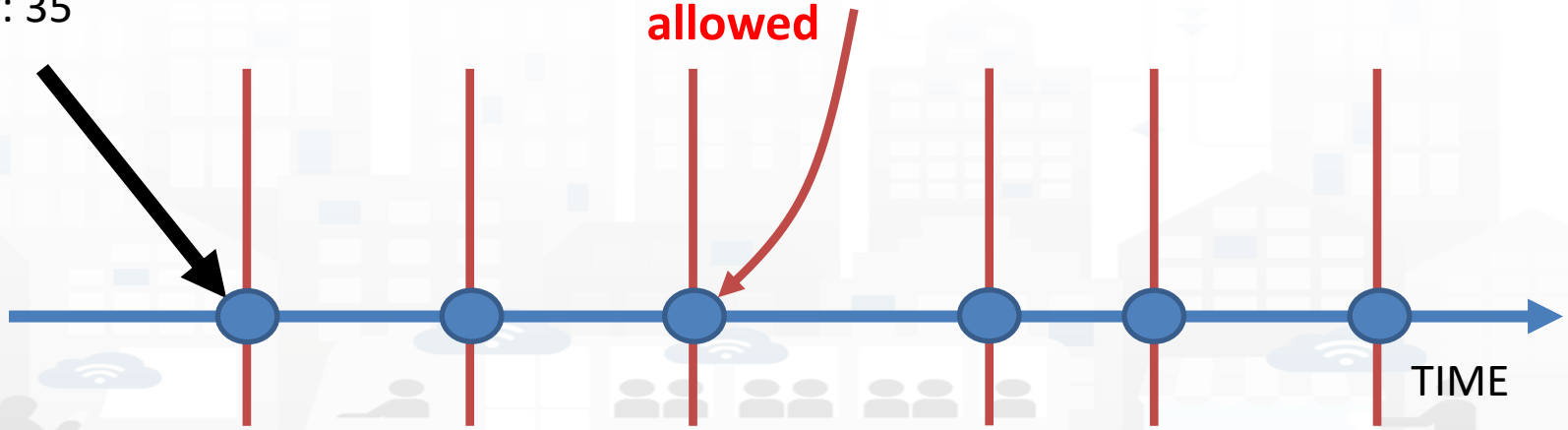
IOT Device

Sends a message

Message (
timestamp: 02-04-2020 at 10:30,
Temperature: 29.34,
Humidity: 35
)

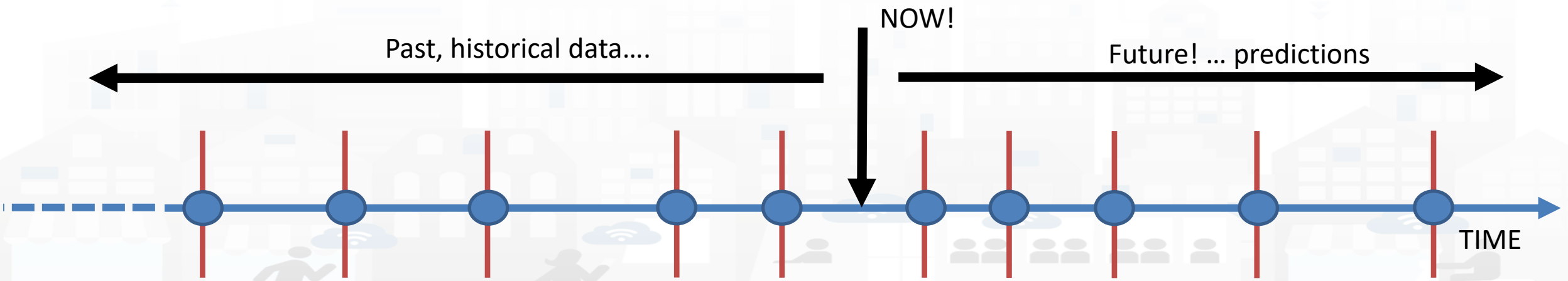
dateObserved	Temp	Humidity
02-04-2020 10:30	34.5	23
02-04-2020 10:40	36.5	24
02-04-2020 10:50	36.0	22.5

- A set of data coming from an IoT Device with multiple sensor become a time series of values for devices.
  - For example: taking a new measure every 10 minutes (Red Lines)
  - Non regular rates can be valid data as well.
- Each new measure in Snap4City is conventionally time located in «dateObserved», which has to be **Unique.**
  - **Only one message per dateObserved is allowed**

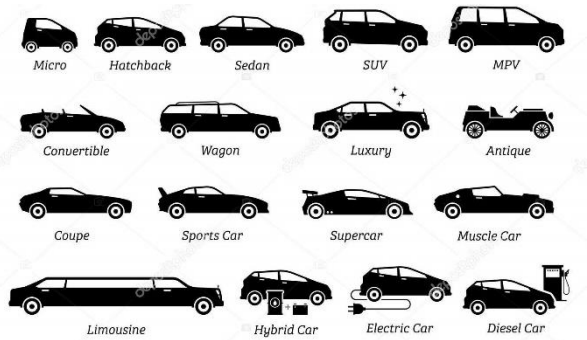


Time Series: they are data streams

- As soon as you have registered an IoT Device
  - You are ready to get Future data, may be arriving in PUSH
  - Recall and store historical data as well, but they have to be
    - recalled in PULL with some IoT App.
    - Loaded in PULL with some File or Data Table Loader



Mobile Devices



Mobile Device Models

Mobile Device
- Name:…..
- Model:…..
- Spec:…

Mobile Device Variables
- ID:
- **dateObserved: ……..**
- Status: ready
- Temperature: 70%
- Gasoline: 35%
- Velocity: 231,3 Km/h
- **Position: 44.3223, 11.3432**
- …..

- They are a special case of IoT Devices
  - they are managed as IoT Devices in the system
- They are classified in terms of nature/subnature
- For Searching and showing on maps and dashboards, they are different
  HLT of Mobile Devices can be:
  - **Mobile Device Model**, for example: «sedan»
  - **Mobile Device** name, for example: «BMW JD7356HD», «Ford KO786KK»
  - **Mobile Device Variable**, for example: «velocity»

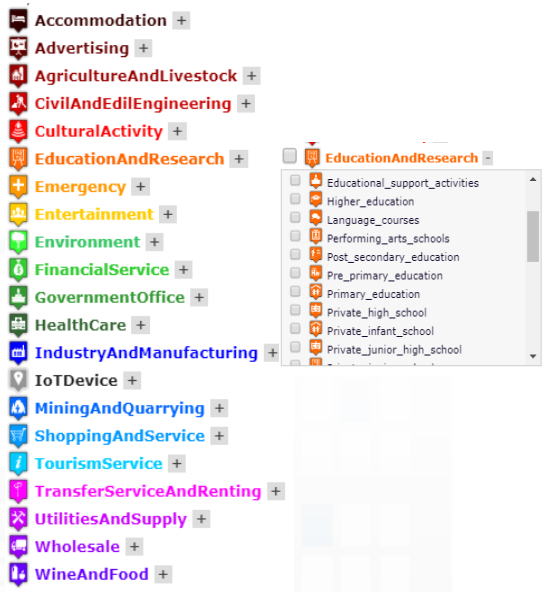
Sensor/Sensor-Actuator

Sensor Device

- Name:…..
- Model:…..
- Position: …….

Sensors

- **dateObserved: …….**
- ID:
- Status: ready
- Temperature: 70%
- WaterLevel: 35%
- UsedCapsBox: 30%
- Power: OK
- …..



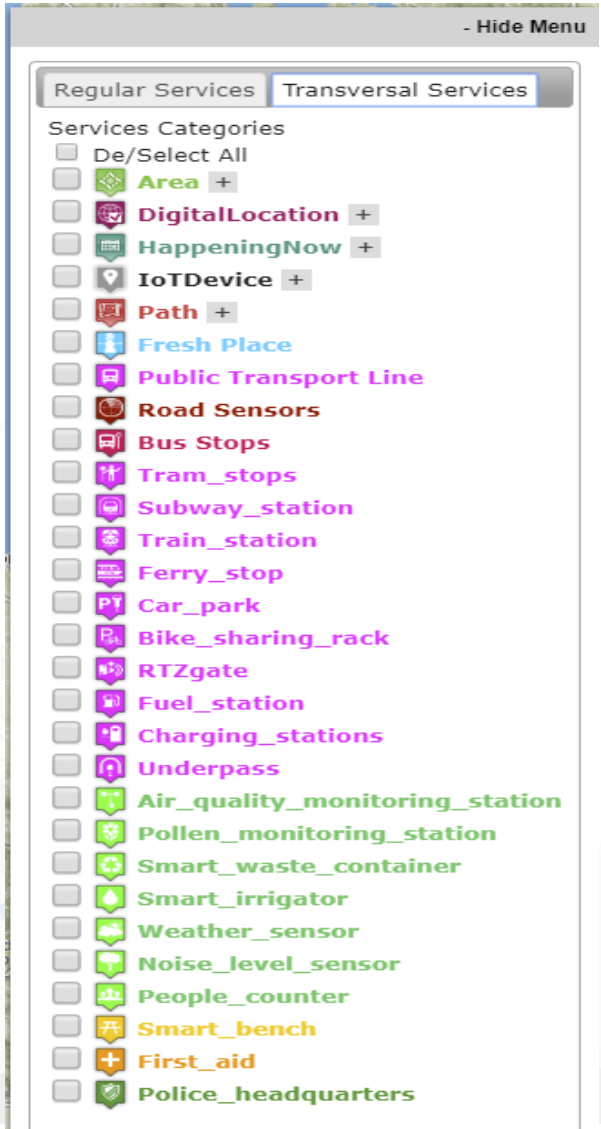
- They are classified in terms of nature/subnature
- For Searching and showing on maps and dashboards **HLT of Sensors/Sensor-Actuator** can be:
  - **Sensor Device** name, for example: «mycoffemachine1», «CM23»
  - **Sensor/sensor-actuator** is a variable of a Sensor Device, for example: «Temperature»
- They do not have a model, while, in KB, have a reference process from which their real time data are collected from the field, from gateways, etc..

POI, Point of Interest

- They are
  - classified in terms of nature/subnature
  - relevant services with codified metadata to simplify the massive management of huge amount of POIs
  - mapped on Knowledge Base on **specific GPS location**
  - Do not move over time
  - represented as PIN
- Do not have Time Series for variable over time
- May sporadically change over time

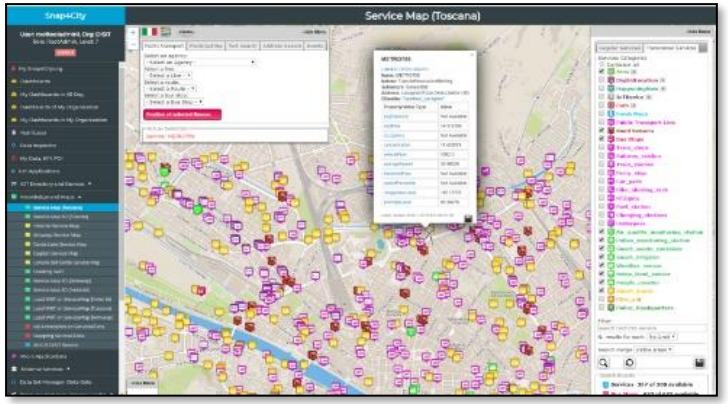
Access to Point of Interest information, POI

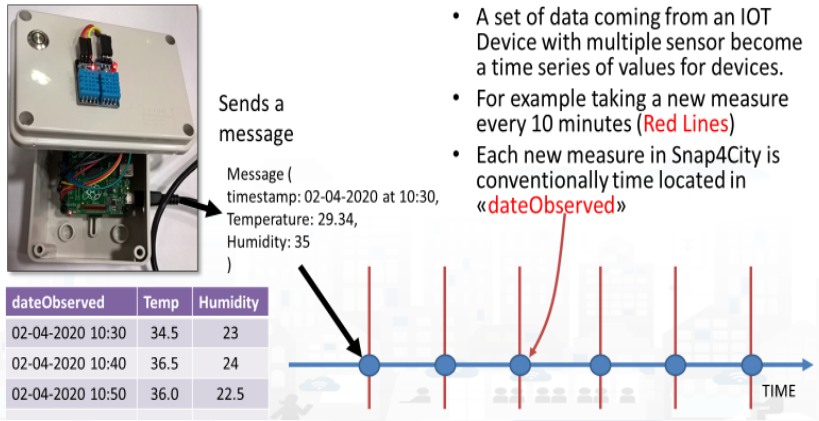
- **POI**: point of interest
- **type**: macro (nature) and subcategories (subnature)
- **Position**: GPS, address, telephone, fax, email, URL, …
- **Description**: textual, multilingual, with images, …
- **Link** to dbPedia, Linked Open Data
- **Links to other services**
- **Real time data if any:** sensors data, timeline, events, prices, opening time, rules of access, status of services, status of queue, etc..
- *See transversal services on ServiceMap*
  - *Regular and in test platform*



Data Ingestion Stragey

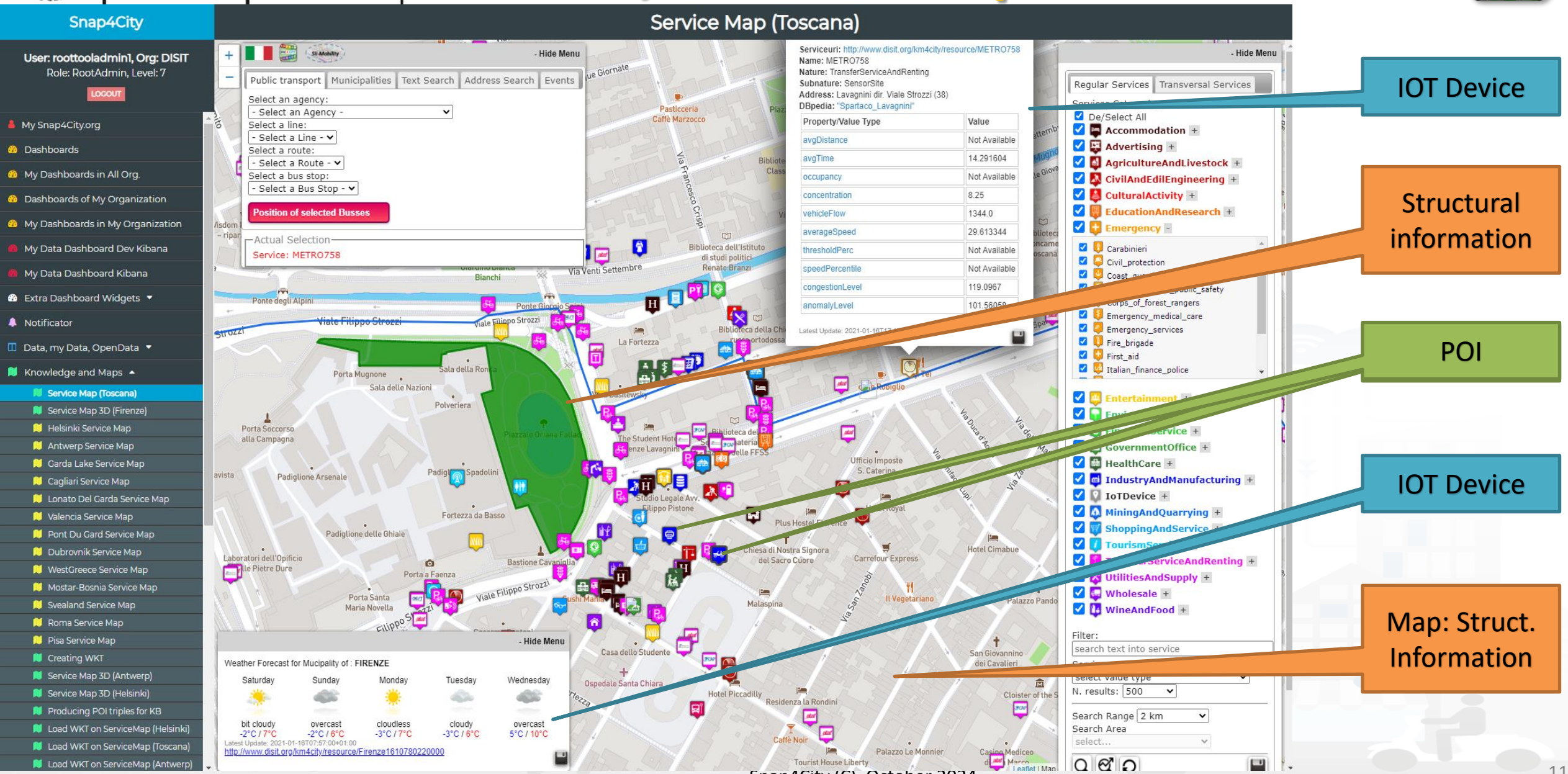
- **Structural Data**: Maps, orthomaps, geolocations, roads, etc.
  - Typically arrive as database, GIS data, etc.
  - **Suggested approaches**: **IoT App, OSM → SM, ETL**
- **POI (point of interest):** info point with geolocation as services, museums, restaurants, banks, email, urls, etc.
  - Typically arrive as: excel files, GIS data, etc.
  - **Suggested approaches**: **POI Loader, IoT App, ETL**
- **IoT Devices, Data Tables,… (Devices and Virtual Devices/KPI), including**
  - Description, including geolocations, etc.
  - Time Series: measures that change over time,
  - They can also move → **IoT Device Mobile, Data Tables**
  - Typically arrive as:
    - description and real time values or additional values
    - Excel files with description and data all together
  - **Suggested approach**: **Data Table Loader, IoT App, Brokers, ETL**
    - IoT Brokers also send data in real time





ETL: deprecated approach in V2

KB, ServiceMap



IOT Device

Structural information

POI

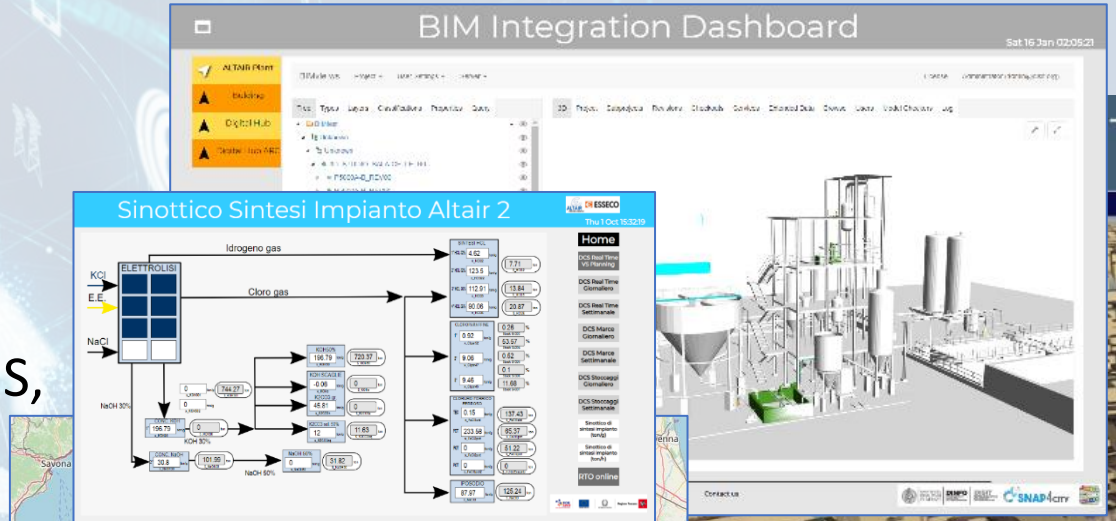
IOT Device

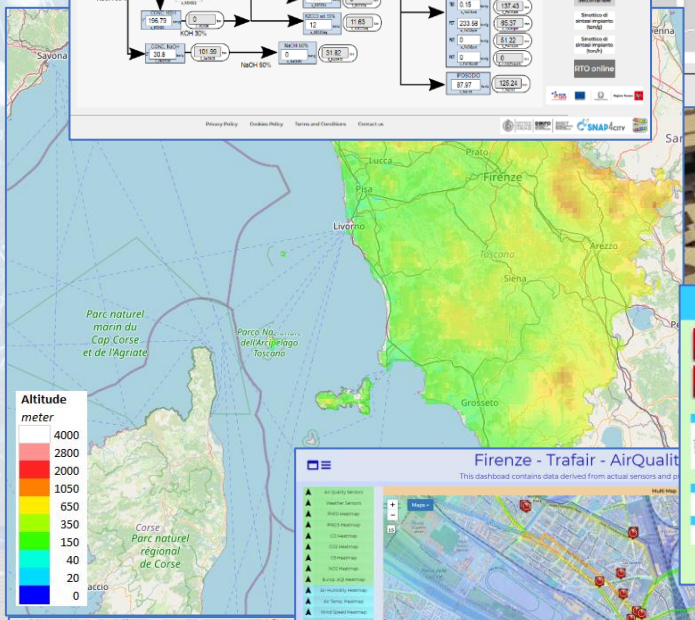
Map: Struct. Information

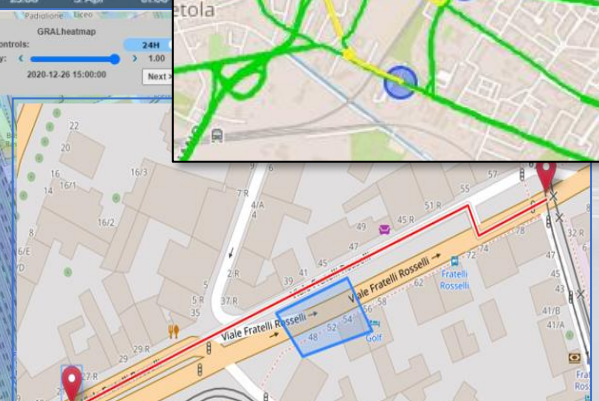
High Level Types

Snap4City (C), October 2024

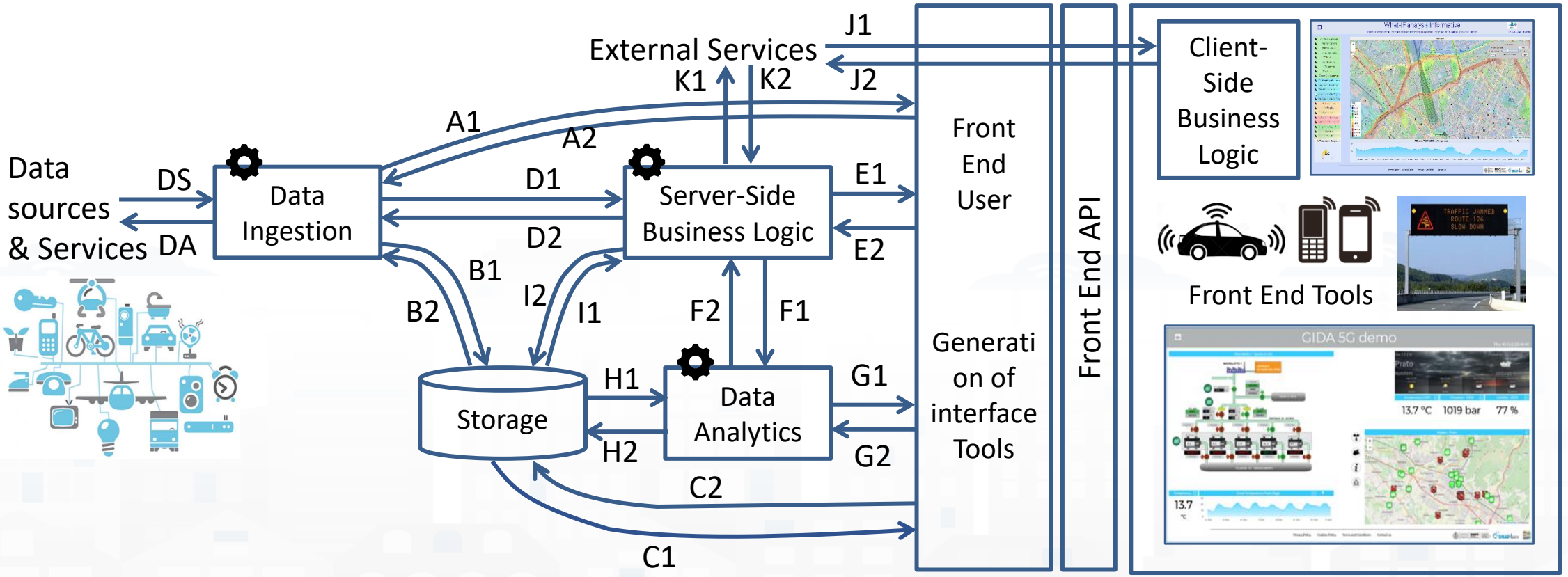
- POI, IOT Devices, shapes,..
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, ..
- traffic flow, typical trends, ..
- trajectories, events, Workflow, ..
- 3D Models, BIM, Digital Twins, ..
- OD Matrices of several kinds, ..
- Dynamic icons/pins, ..
- Synoptics, animations, ..
- KPI, personal KPI,..
- social media data, TV Stream,
- routing, multimodal, constraints, ..
- decision scenarios, ….
- etc.



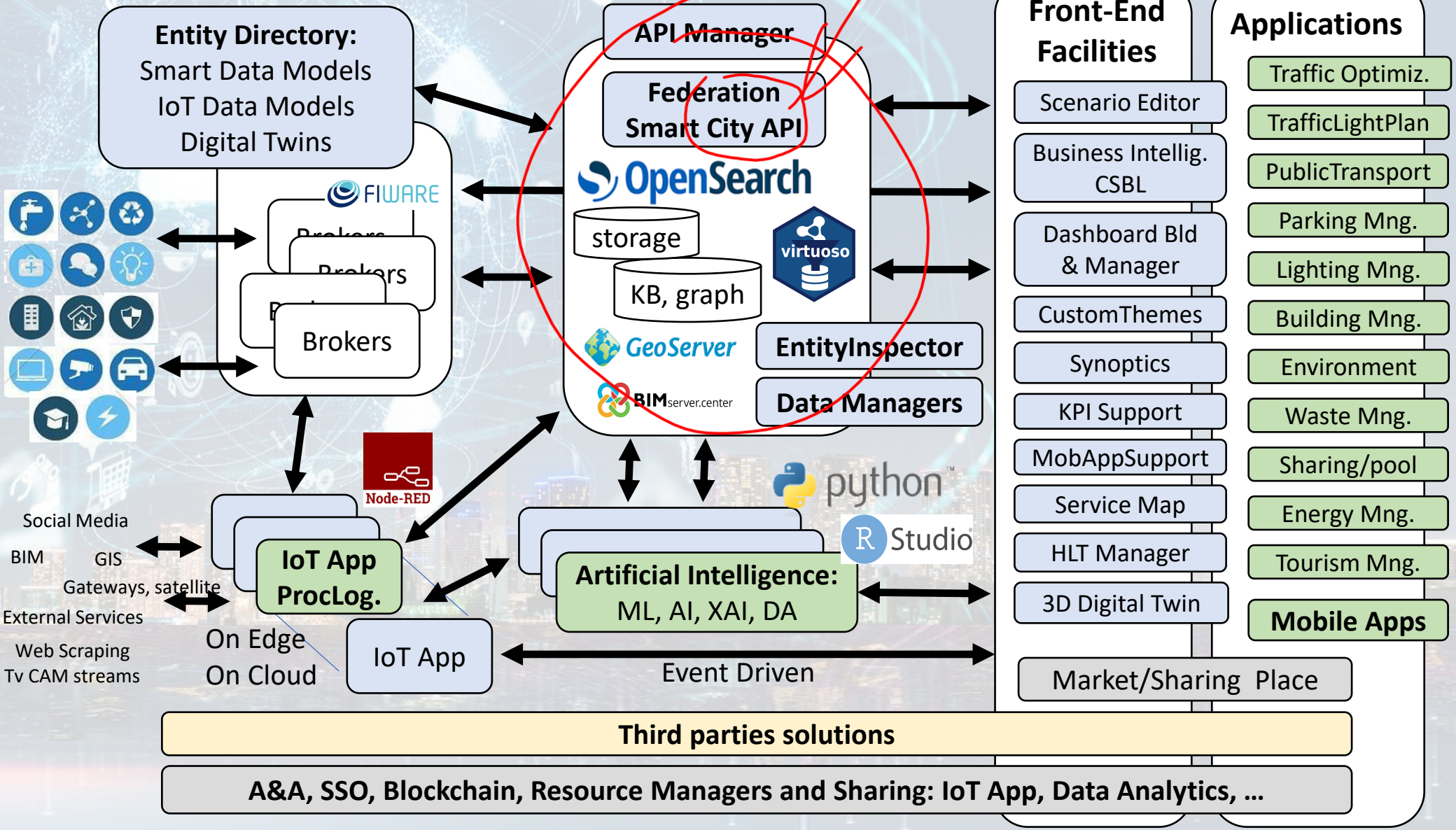




Interoperability of Snap4City Platform


External Services
J1
J2
K1
K2
A1
A2
Data
sources
& Services
DS
DA
Data
Ingestion
D1
D2
Server-Side
Business Logic
E1
E2
B1
B2
I2
I1
F2
F1
Storage
H1
H2
Data
Analytics
G1
G2
C2
C1
Front
End
User
Generati
on of
interface
Tools
Front End API
Client-
Side
Business
Logic
Front End Tools
GIDA 5G demo

Technical Architecture



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- **Database**: Open Search, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Elastic Search, Phoenix, PostGres, MS Azure, ..
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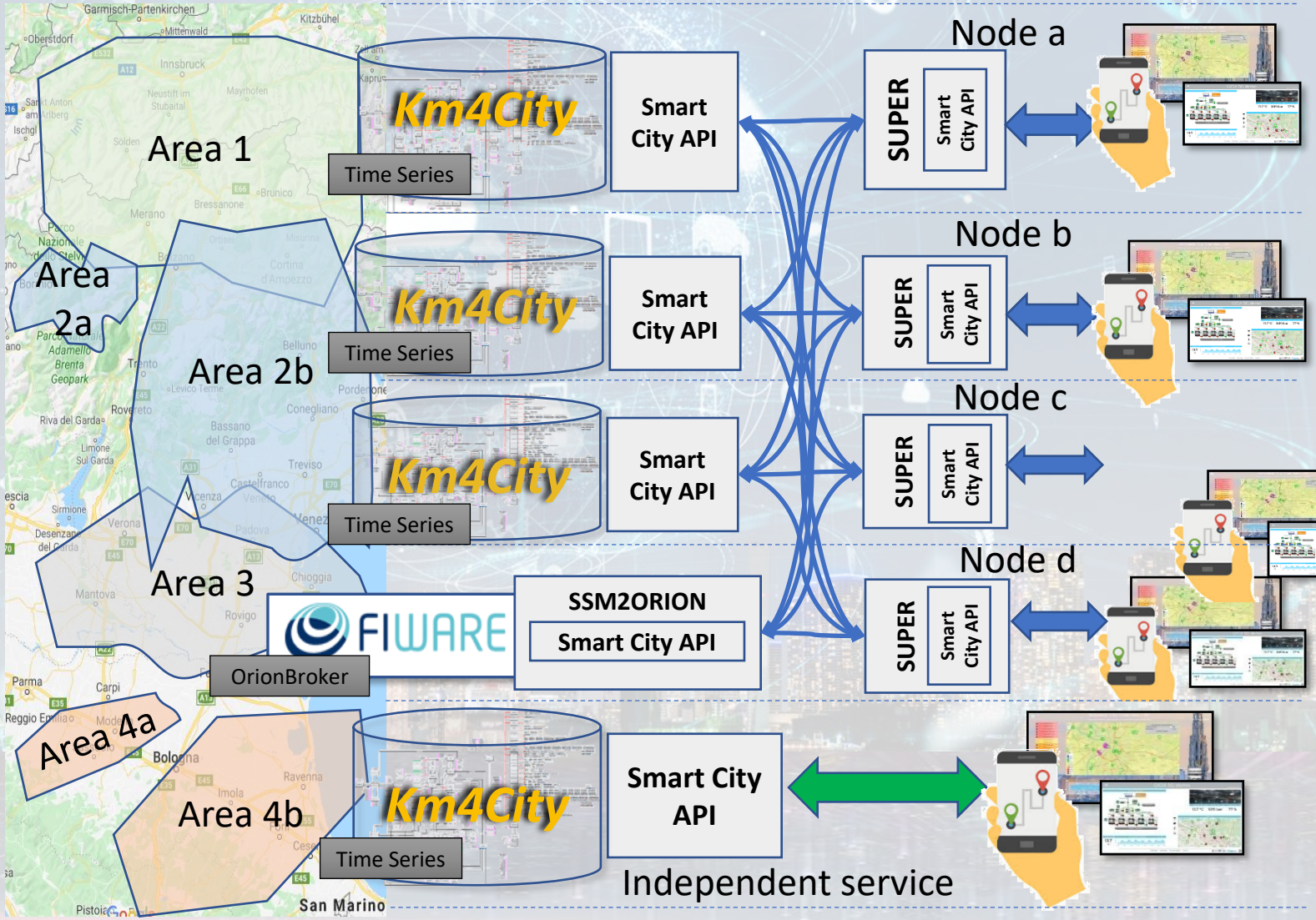
- **Social**:Twitter, FaceBook, Telegram, ..
- **Events**: SMS, EMAIL, CAP, RSS Feed, ..
- **OS**: Linux, Windows, Android, Raspberry Pi, Local File System, AXIS, ESP32, etc.

https://www.snap4city.org/65

Federation of Smart City Services

Knowledge Base
Semantic Reasoners

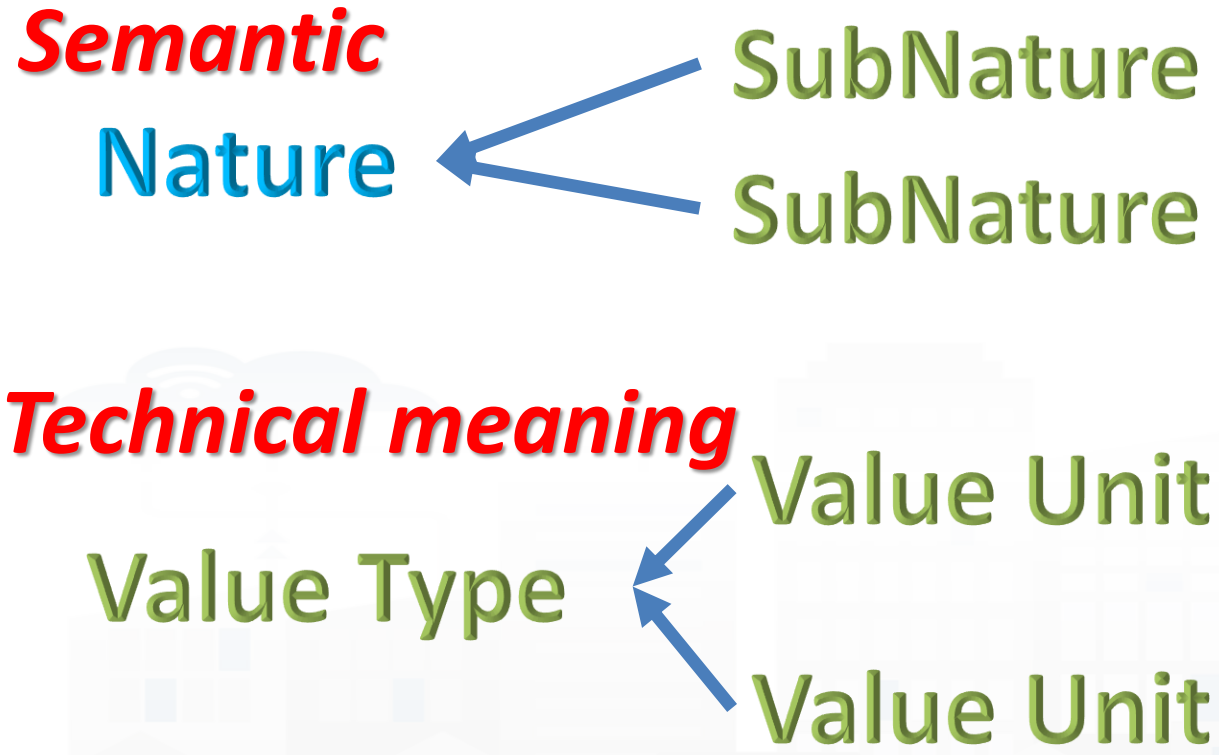


- Km4City **Semantic Reasoner**
- **ServiceMap** interoperability
- **Seamless for multiple Mobile Apps**
- **Smart City API**
- **Super**:
  - distributed access and sharing services
  - Each city control its own data
  - Final user can pass from one city / area to another in seamless manner: without changing the mobile Apps

Dictionary for Data Fields

Semantics and Technical Meaning

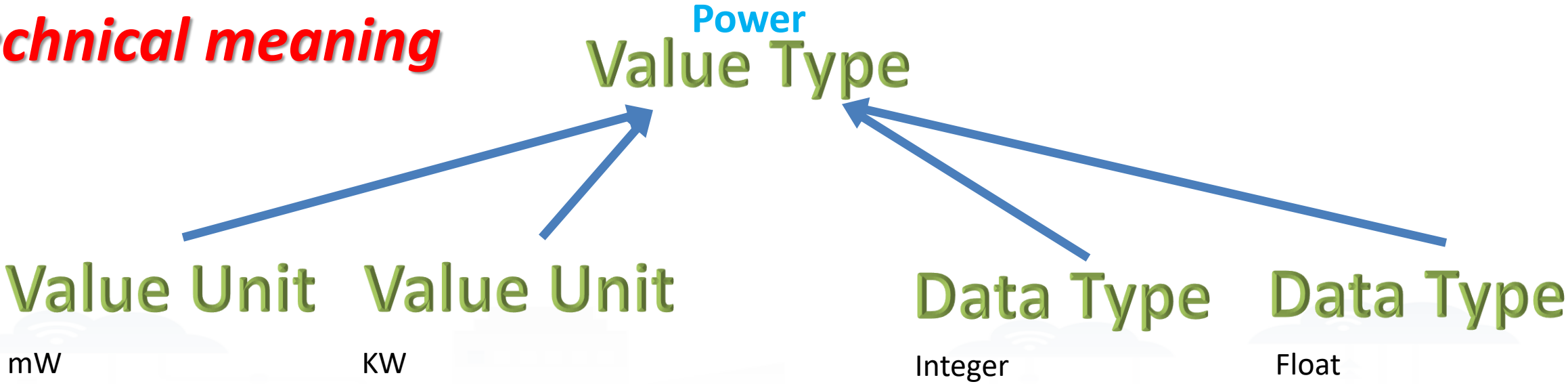
Unified Data and Services Model/Classification



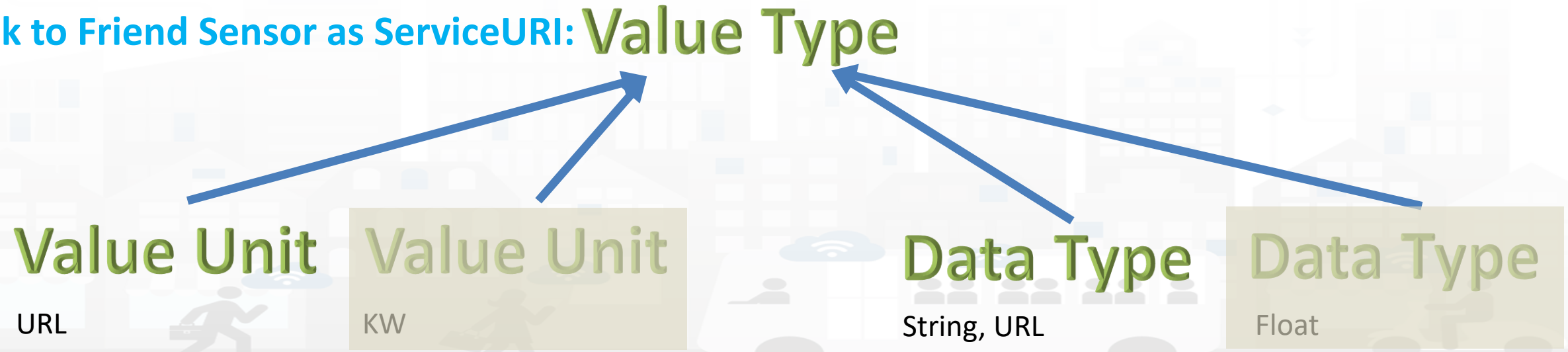
- Exists a Dictionary for the 4 categories
- They are related each other and not all values are possible
- Right setting lead to right rendering on graphs and automated combinations and processing
- The Disctionary is used by many tools

For example

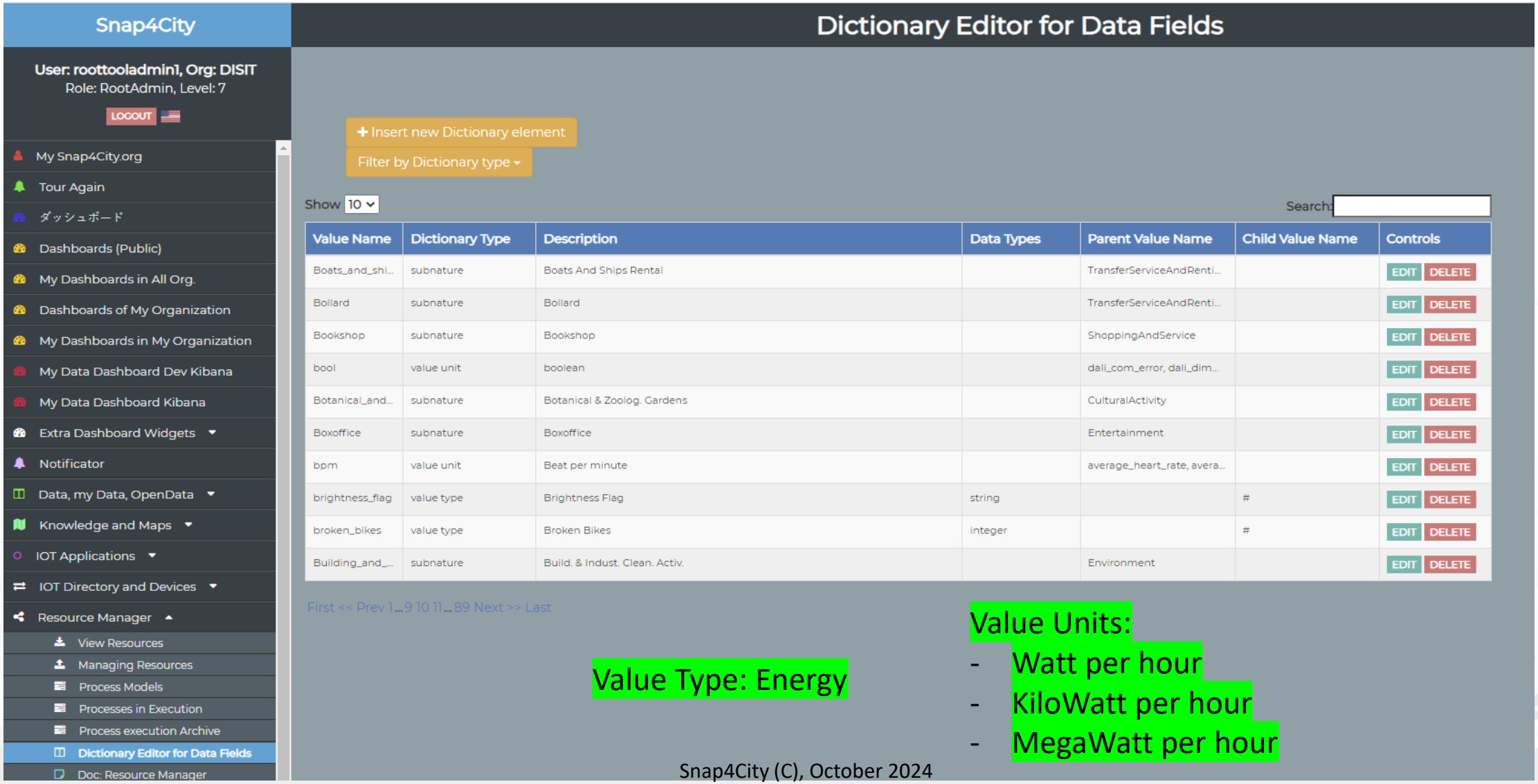
Technical meaning



Link to Friend Sensor as ServiceURI:



Example of Energy and its Value Units



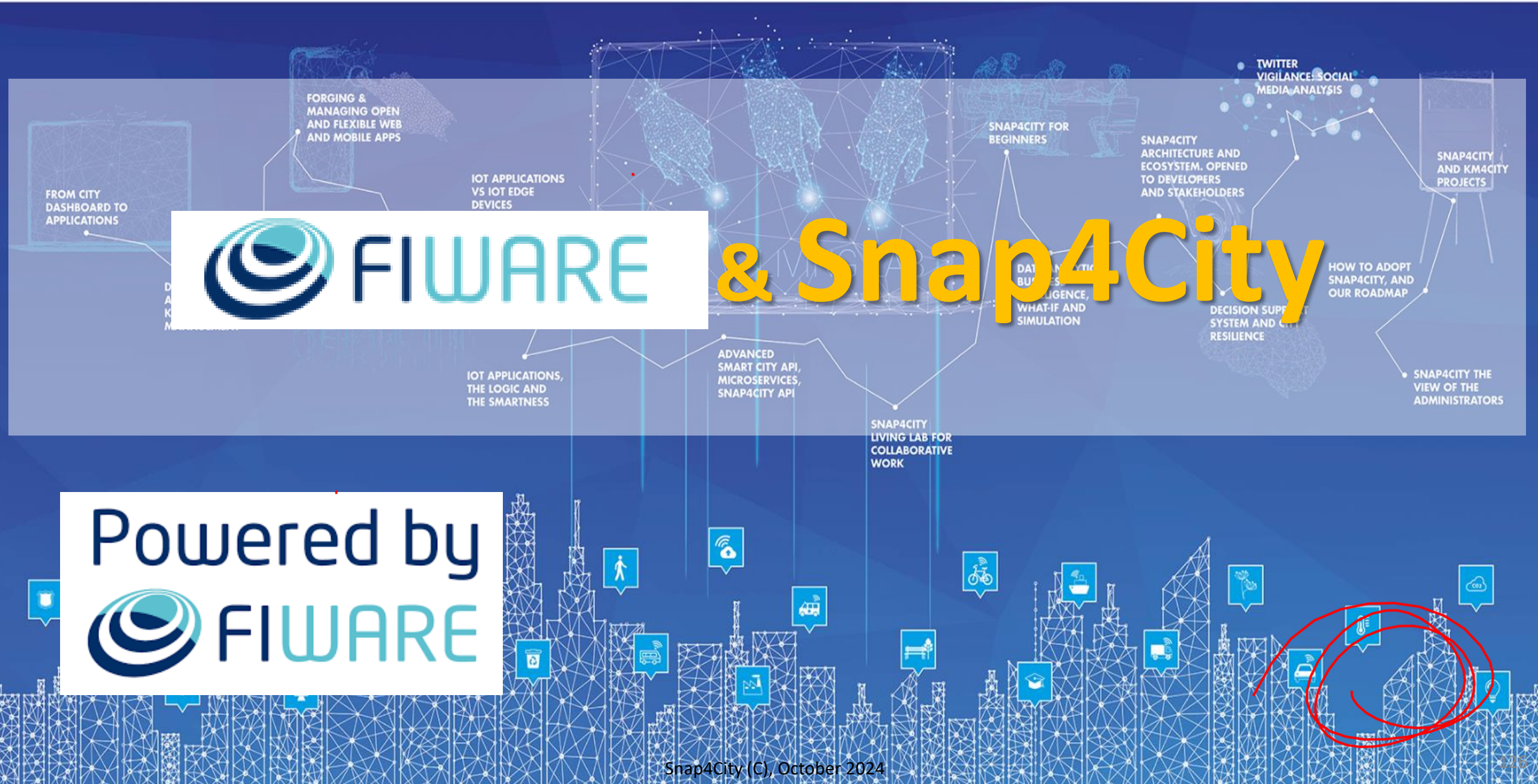
Value Type: Energy

Value Units:
- Watt per hour
- KiloWatt per hour
- MegaWatt per hour

Please note on: Data Type

- Value Types have only a few number of **Data Types** because they represent how the data area treated into the system
- Therefore main Data Types are:
  - **Float**: numbers with decimals large as you like, etc.
  - **Integer**: numbers, booleans (0/1), etc.
  - **String**: url, links, names, id, descriptions, status code, etc.
  - **Json**: structured data, vector, matrices, etc.
  - …..

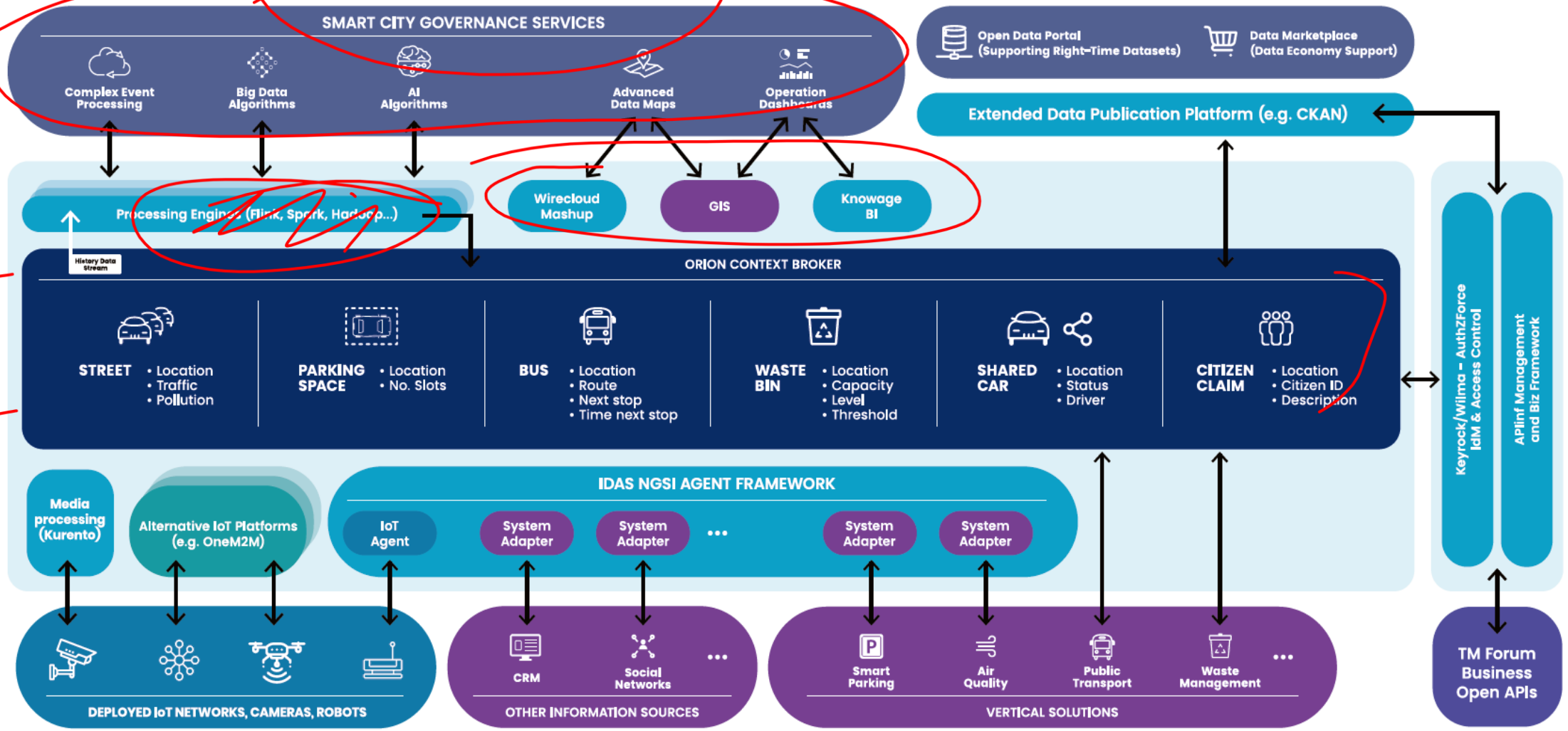
SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES



FIWARE & Snap4City

Powered by FIWARE

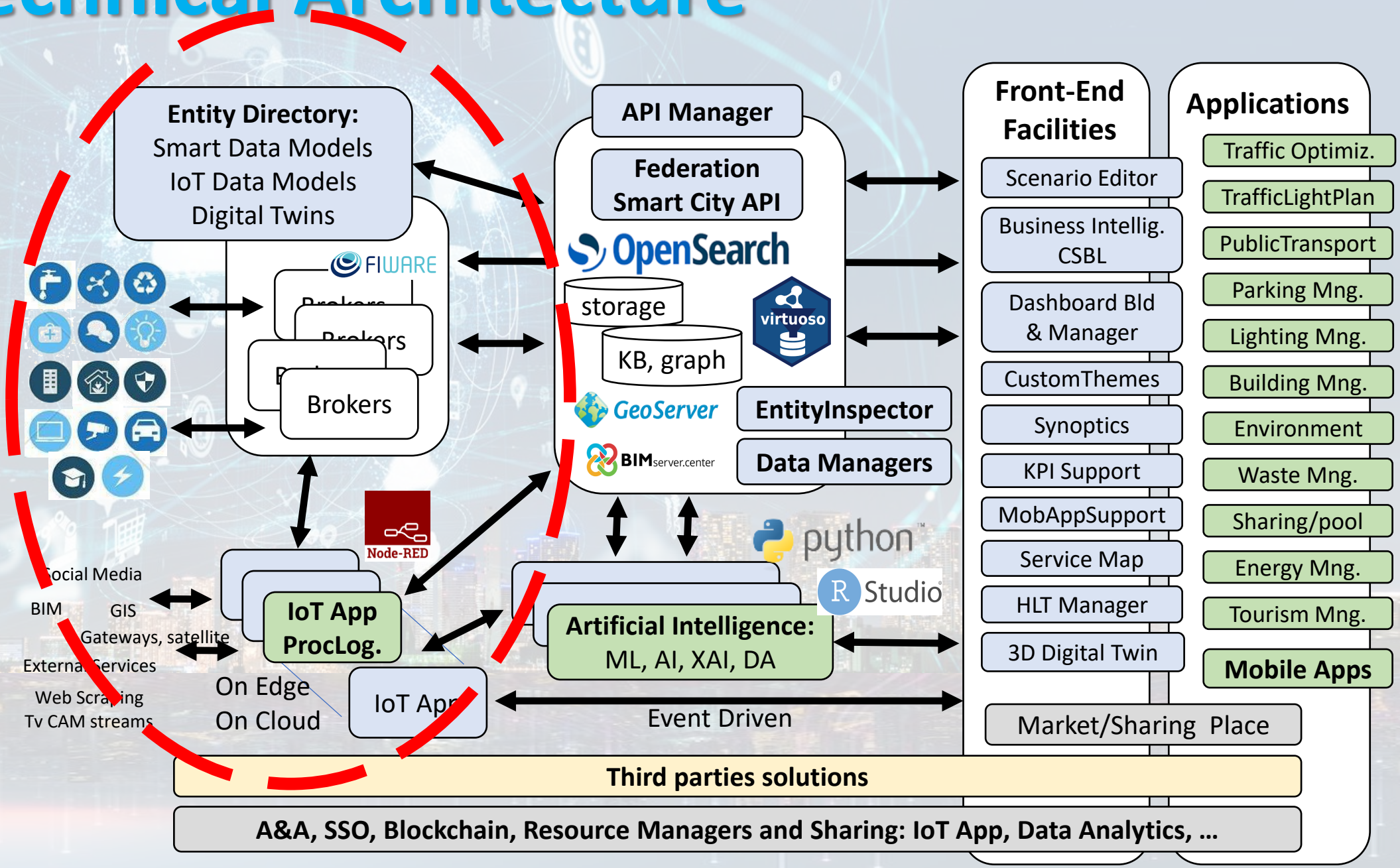
THE FIWARE SMART CITIES REFERENCE ARCHITECTURE



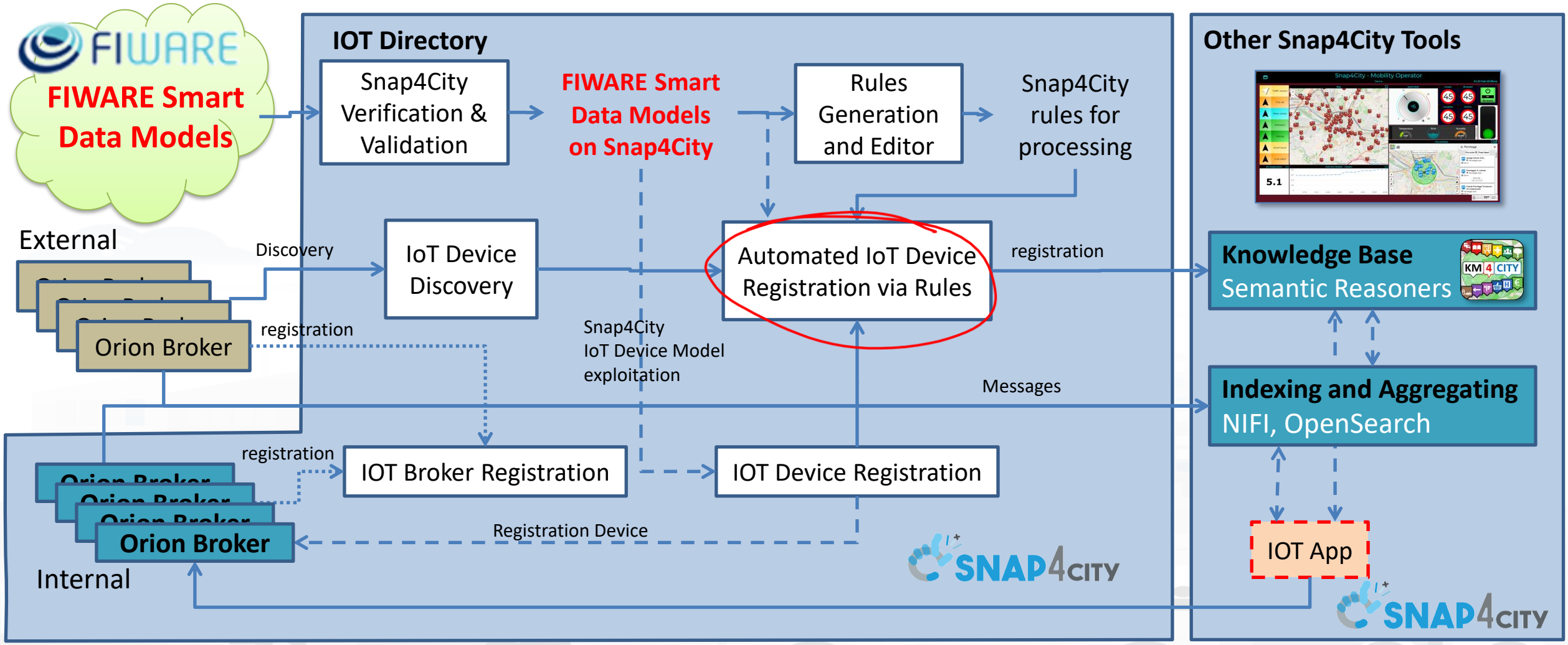
- Snap4City - Powered by FIWARE Solution & Platform:
  - https://www.fiware.org/marketplace/product-details/?category=powered&id=snap4city-snap4city
  - NGSI V1, V2 The IOT Orion Broker
  - IOT Orion Broker can connect JSON, MQTT, Lightweight M2M, LoraWAN, OPC, SigFOX, etc. see FiWare Https://www.fiware.org
- Snap4City - FIWARE Training Services:
  - https://marketplace.fiware.org/pages/solutions/03bccd83a0e1b0398ba7a0bf
- Snap4City - FIWARE Consultancy Services:
  - https://marketplace.fiware.org/pages/solutions/907f5ecc63927f643dd8421b
- **Snap4City is compatible** with all the above protocols
  - via IOT Orion Broker,
  - via IOT Applications.
  - via direct connection on ETL processes on their corresponding IOT brokers, and/or
- **Snap4City is also compatible** with many other protocols, see the table reported in page: https://www.snap4city.org/65

Powered by FIWARE

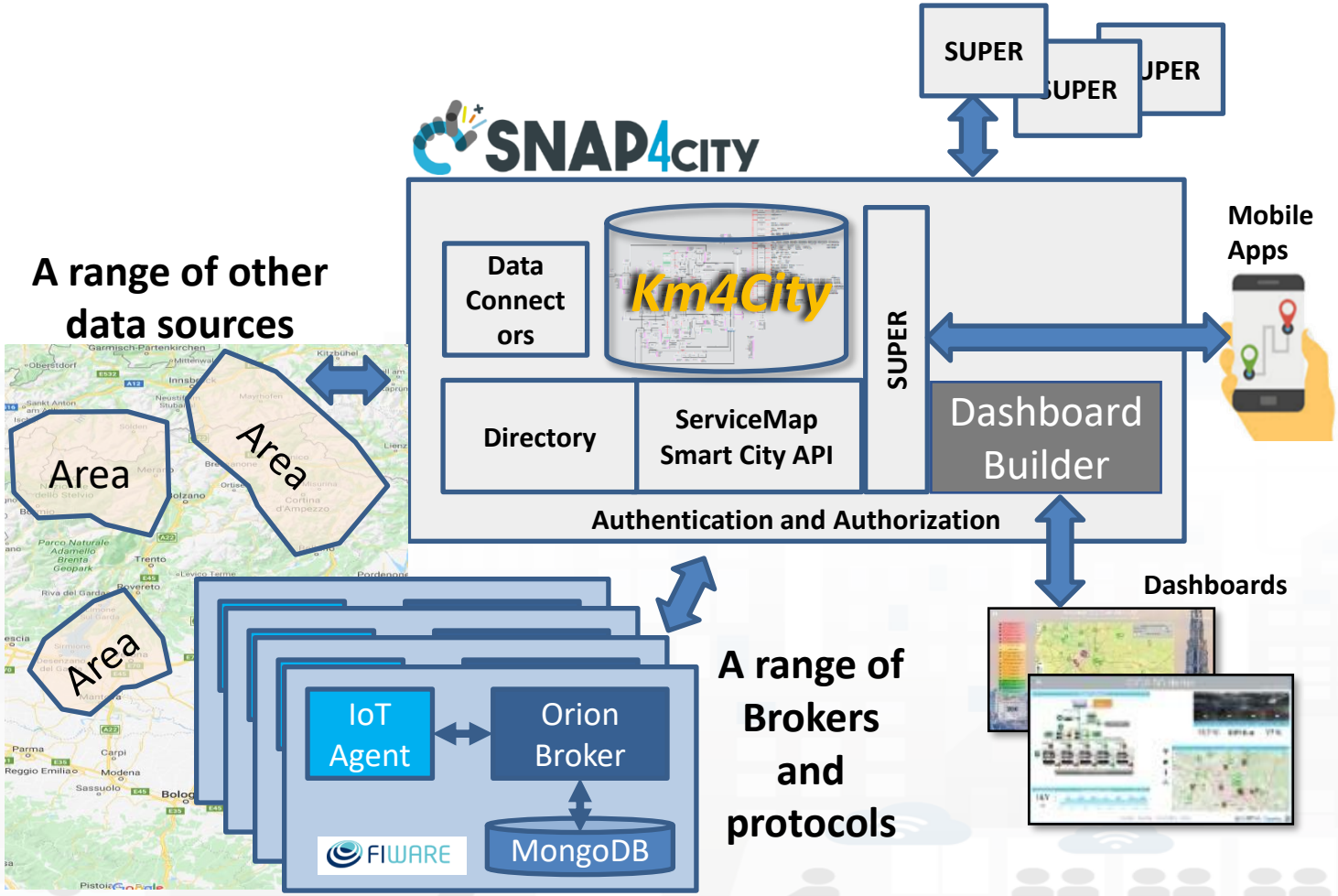
Technical Architecture



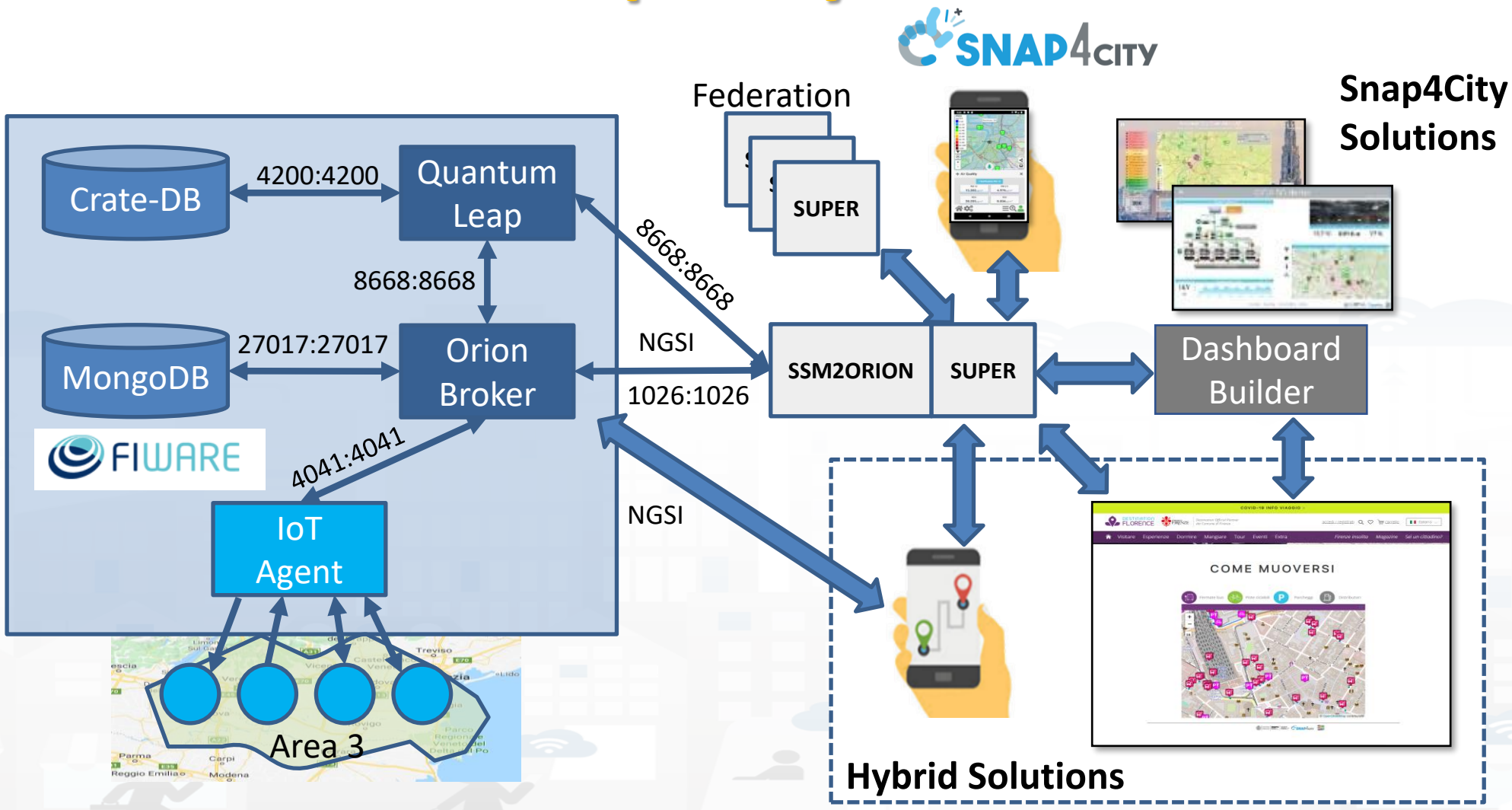
Exploiting FIWARE Smart Data Models



Snap4City IoT Registration and Access



Federation of Snap4City vs ORION Broker



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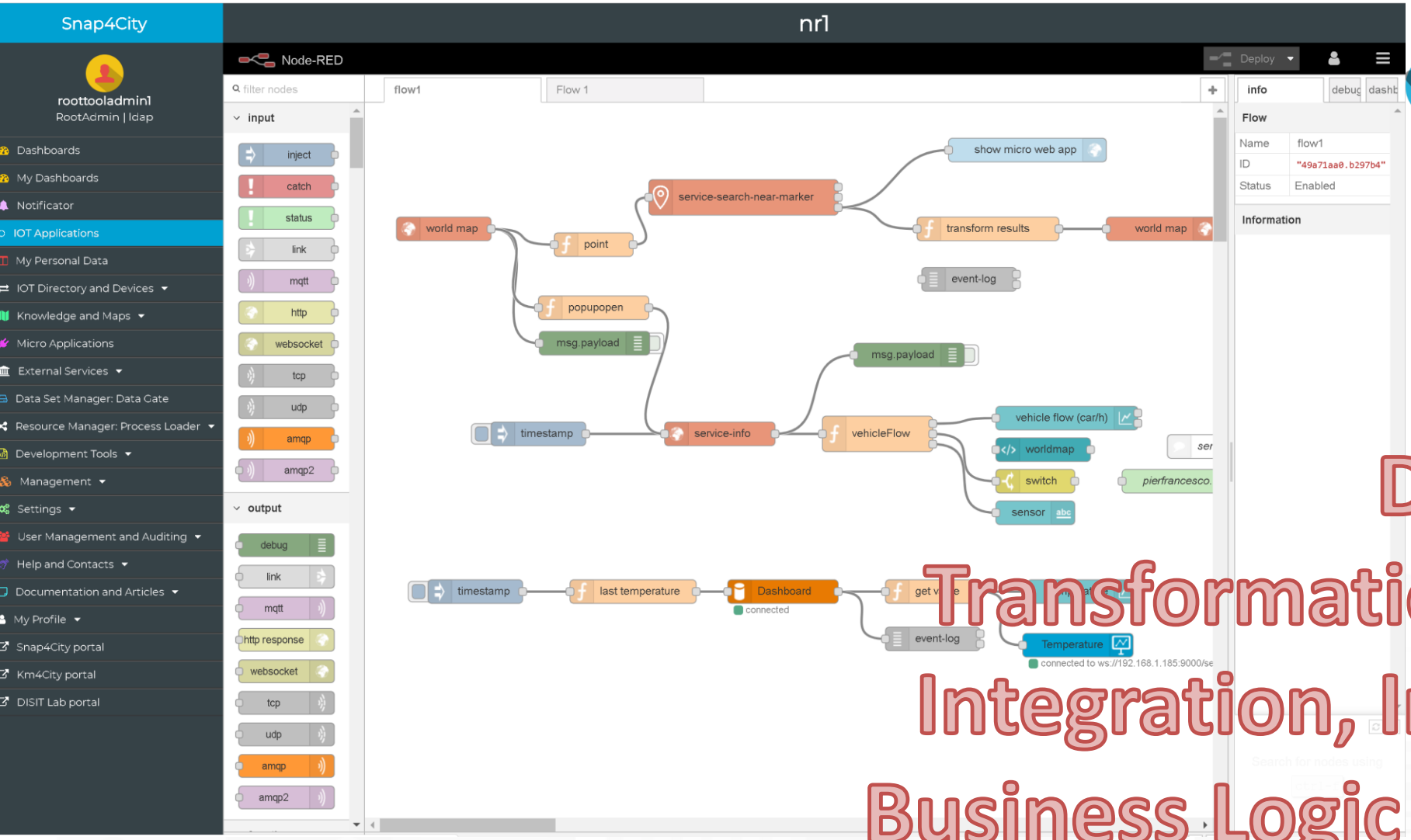
https://www.disit.org/
Paolo Nesi, paolo.nesi@unifi.it

IoT App / Proc.Logic

https://www.snap4City.org **https://www.Km4City.org**



Editing IOT Applications

Data Adapation

Transformation, Conversion

Integration, Interoperability

Business Logic vs Dashboards

Data Analytics control

Everywhere: Cloud, on IoT Edge Devices

IOT Application Editor: NODE-RED

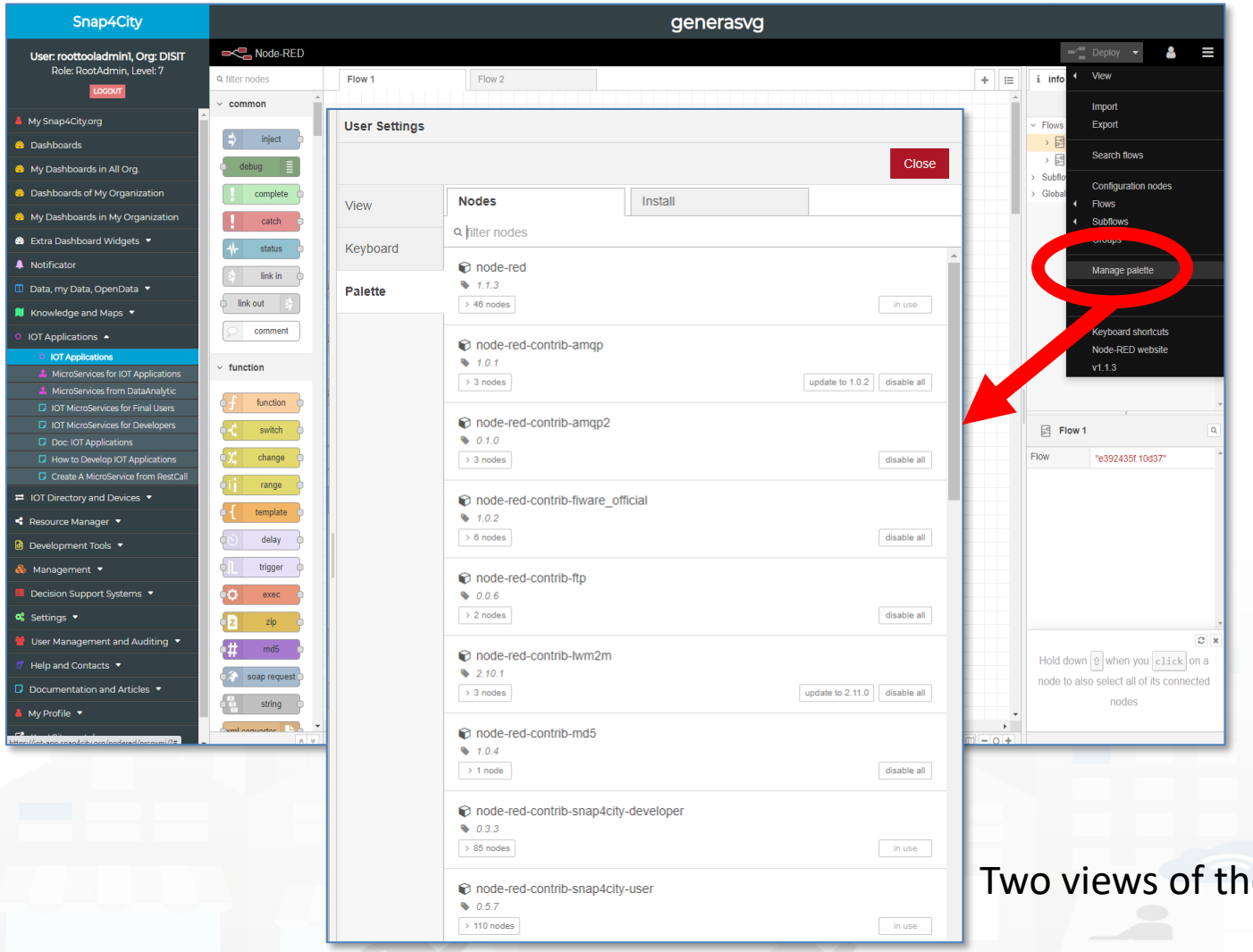
- In the **IOT Application of Snap4City**, it is possible to:
  - Execute flows that process data as: Event Driven, Batch (periodic or not)
  - Create multiple concurrent Flows for each IOT Application
  - Create subflows as macros to be reused
  - Create Groups of nodes as macro
  - **Save/load**, **share**, of nodes, flows and applications with other users via
    - the Snap4City Resource Manager or
    - with JS Foundation or
    - via email, skype, file sharing in general
  - ..

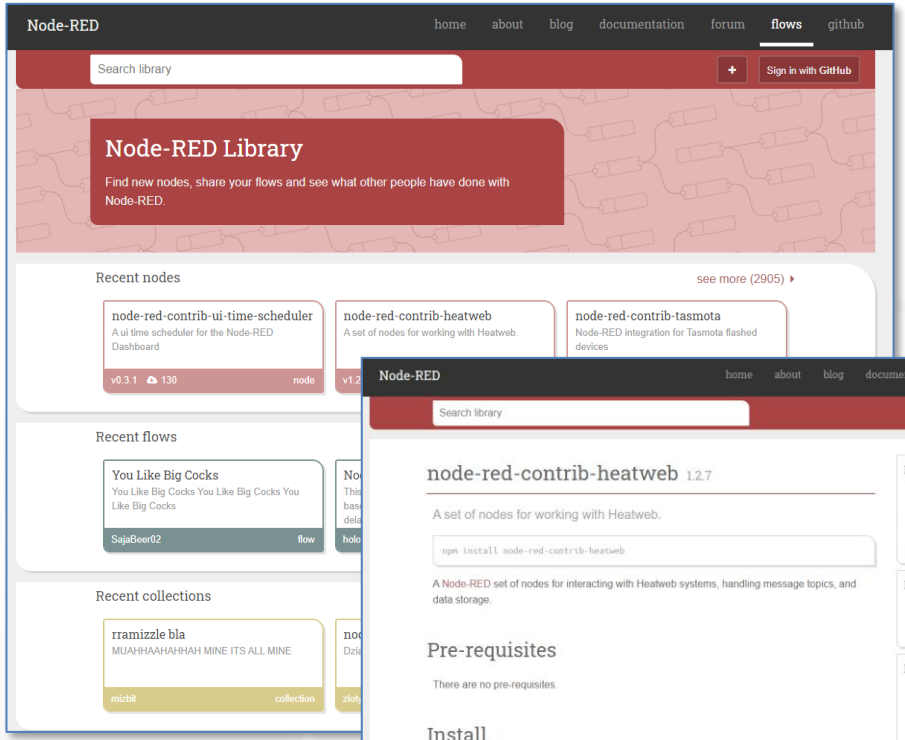
IOT Application Editor: NODE-RED

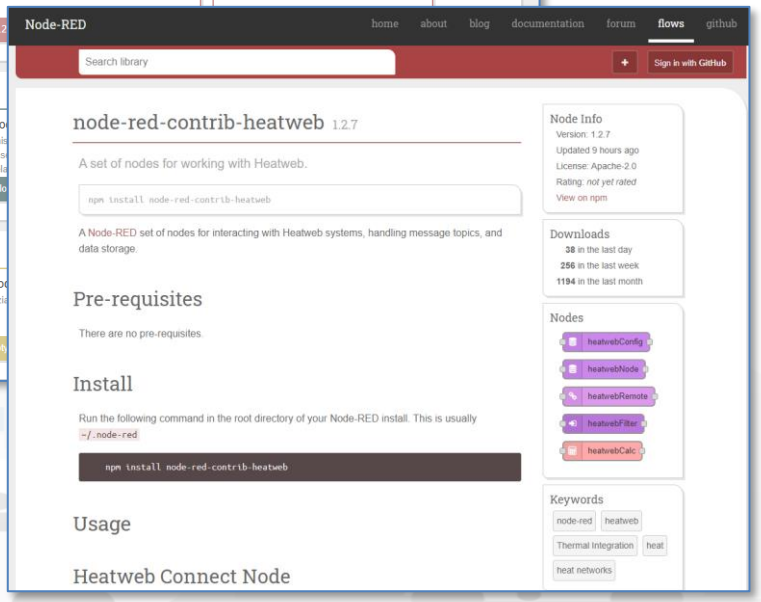
- In the **IOT Apps of Snap4City**, it is possible to Extend the Capabilities:
  - Load other Nodes, segments of flow and entire flows from several sources: email, libraries, S4C repository, etc.
  - Load other libraries of MicroServices/Nodes/Blocks from **Manage Palette**
    - A large set of Libraries of Node is available.
    - The loading may have some limitations for security reasons
  - **Get more IOT Apps** above the Limit that may depend on the organization and/or on personal authorizations, ask to Admin
  - ..

Load Library from Palette

https://flows.nodered.org/

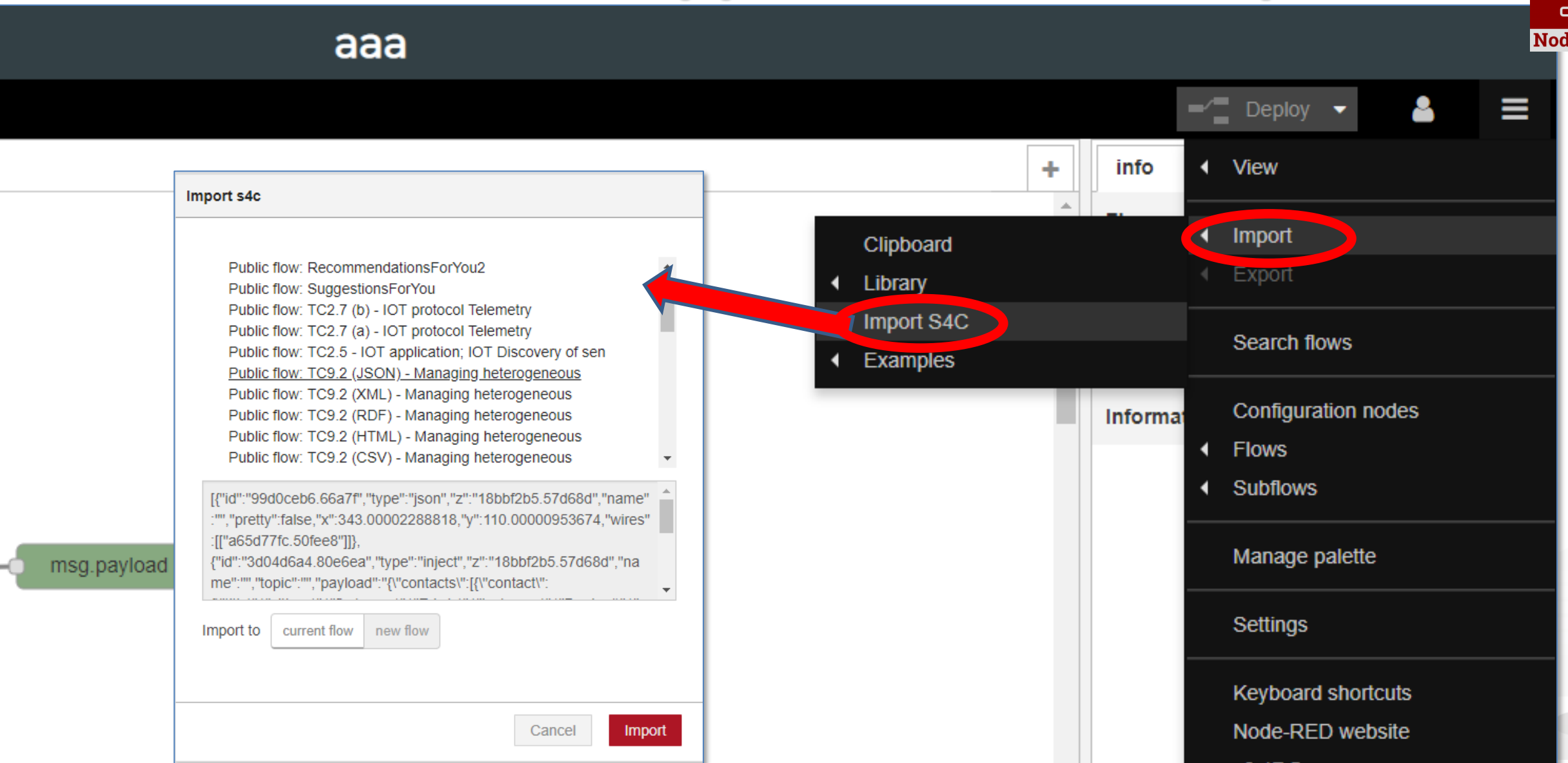




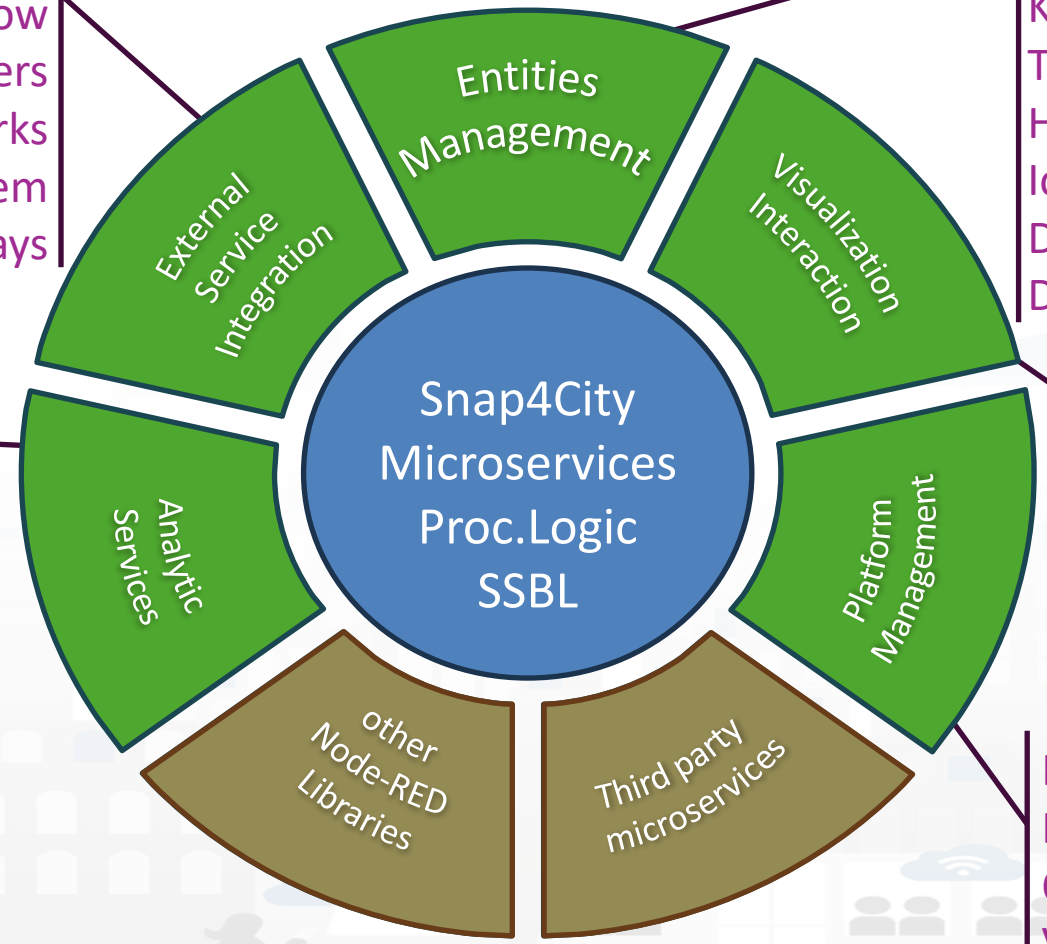


Two views of the same libraries

Load an IOT application of example



MicroServices Areas



Open Data CKAN
Ticket Management, workflow
BIM Servers
Social Networks
Video Management system
Gateways

Data Load / Search / Retrieval
KPI, POI, GIS Data, Scenarios
Time Series, Public transport
High Level Types: heatmaps, ODM,…
IoT / Entity Discovery
Delegation Management
Data Mapping

Data Analytics
Statistic, Optimization
Simulation
Artificial Intelligence
What-if Analysis Support
Geo Utilities Support
Routing & Traffic Flow
MLOps support
Python support
R Studio Support

Dashboards
Widgets: Graphic Libraries
Interactive Widgets
Maps, 3D representations
Synoptics, External Content
Micro Web App

IoTApp Management
Data Logs, A&A, Security
Ownership Management
VPN remote access

Smart City and IOT main needs

Smart City Entities Search: search and access to city entities and their relationships in the city.

Historical Data: search and access to data collected over time into the smart city data aggregator.

Save and Get Personal Data: for many smart city applications, the possibility of saving and retrieval of personal data enables a large variety of smart scenarios for the final users and operators.

Advanced Dashboards: This means to have the possibility of developing a real user interface of the IOT App (to render and produce data for the IOT network).

Data Analytic: The real need in the context of smart City is to have the possibility for a data-analysts of creating some data analytic processes and use it into the flow as MicroService without the intervention of a programmer nor administrator.

IOT Device Connection: This means that the developers expect to have the possibility of using nodes for connecting to a large set of IOT devices using different protocols, and thus connecting to different kind of IOT brokers.

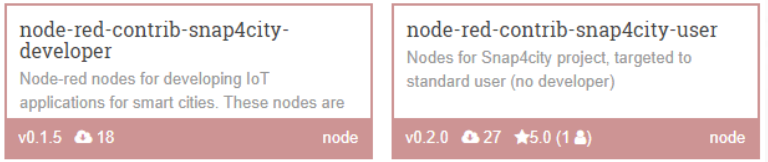
IOT Directory: It should be a single point service for searching, managing and discovering all the IOT Devices which can be connected to the infrastructure by means of a large set of heterogenous IOT Brokers.

IOT Applications

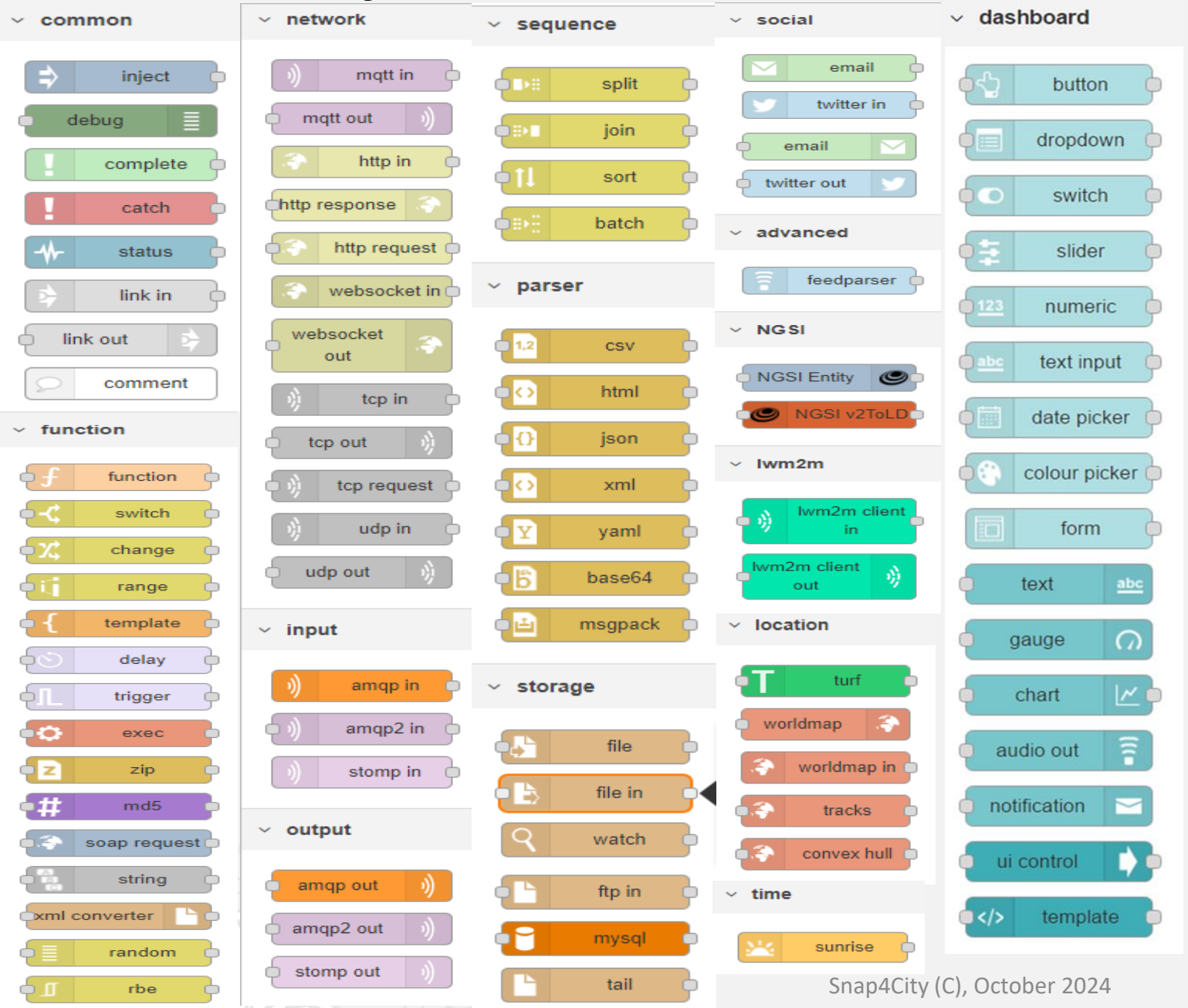
IOT Applications = Node-RED + Snap4City Platform

- A collection of more than **150 MicroServices** have been developed covering the above-mentioned requirements and much more.
- The issue was not only to formalize the MicroServices, but also to create the infrastructure that enable their usage. In many cases, the simple MicroServices hide very **complex** and **sophisticate tools and algorithms (Snap4city Platform)**.
- They are formally distributed as two official libraries of Node-RED nodes (**Snap4City Basic and Advanced**) by the JS Foundation portal.
- They can be **directly installed** in any Node-RED tool of any operating system.

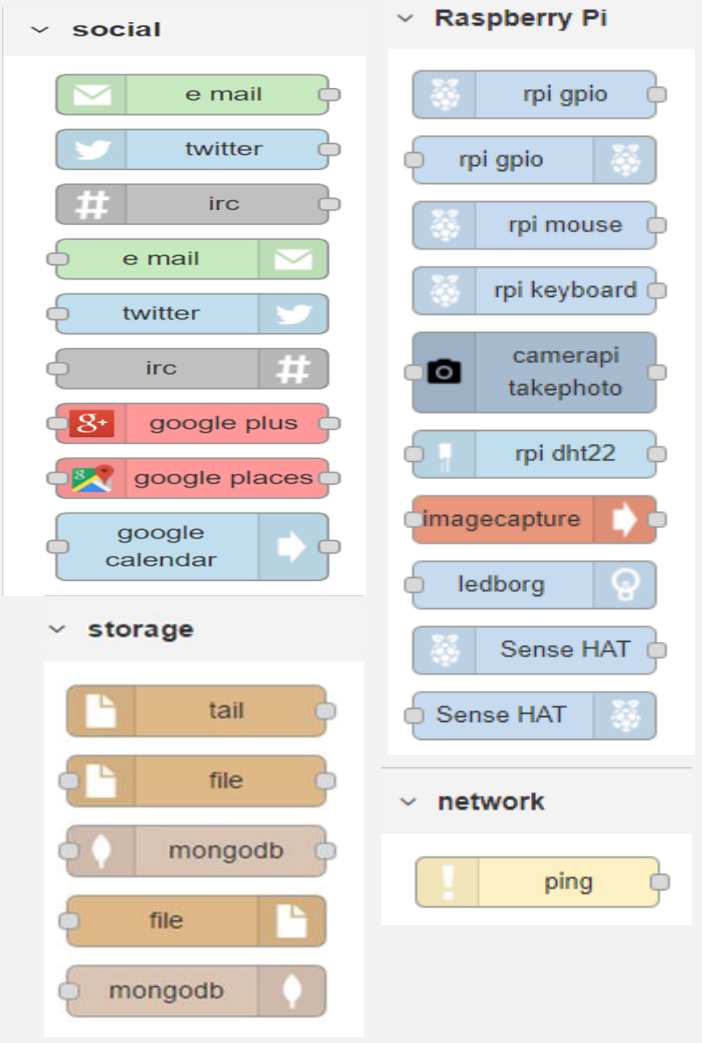
https://flows.nodered.org/?term=snap4city



Basic Node.js Blocks on NodeRed on our Advanced IOT Apps



+ on IOT Edge Raspberry

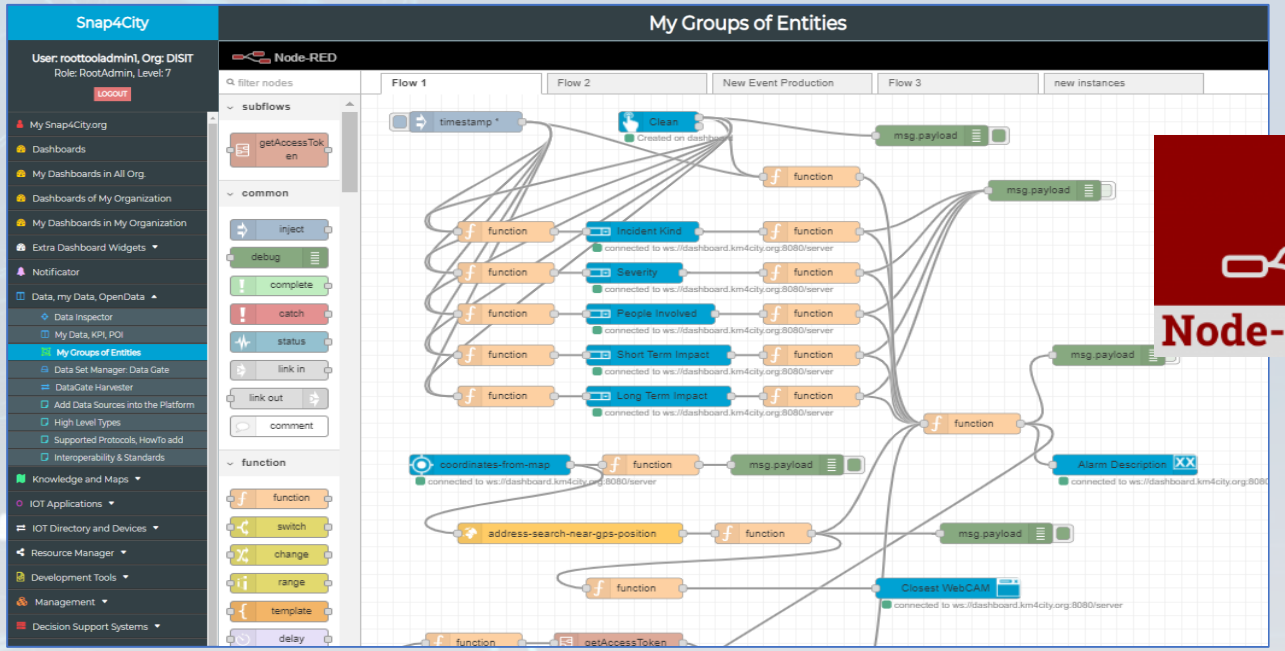


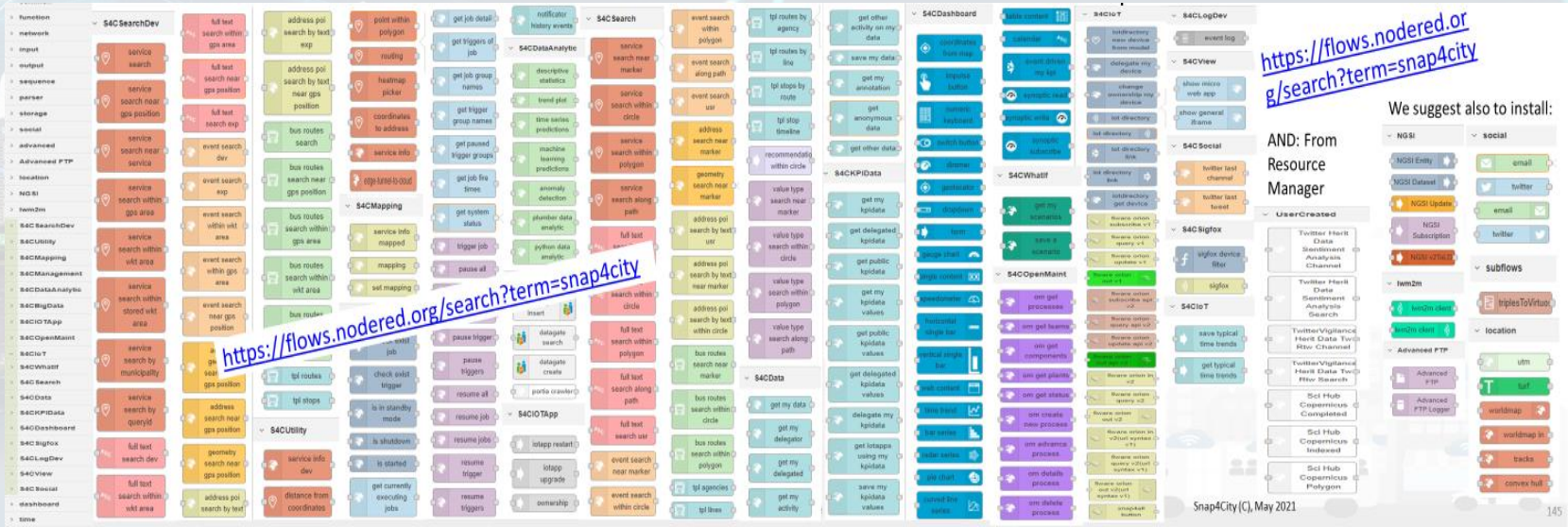
IoT Applications

- **Data ingestion**: more than 70 protocols IOT and Industry 4.0, web Scraping, external services, any protocol database, etc.
- **Data access**: save/retrieve data, query search on expert system, georeverse solution, search on expert system Km4City ontology, etc.
- **Data Transformation/transcoding:** binary, hexadecimal, XML, JSON, String, any format
- **Integration**: CKAN, Web Scraping, FTP, Copernicus satellite, Twitter Vigilance, Workflow OpenMaint, Digital Twin BIMServer, any external service REST Call, etc.
- **Manipulation of complex data**: heatmaps, scenarios, typical time trend, multi series, calendar, maps, etc.
- **Access to Smart City Entities and exploitation of Smart City Services**: transport, parking, POI, KPI, personal data, scenarios, etc.
- **Data Analytic**: managing Python native, calling and scheduling Python/Rstudio containers as snap4city microservices (predictions, anomaly detection, statistics, etc.)
- **User interaction on Dashboard**: get data and message from the user interface, providing messages to the user (form, buttons, switches, animations, selector, maps, etc.)
- **Custom Widgets**: SVG, synoptics, animations, dynamic pins on maps, etc
- **Event management**: Telegram, Twitter, Facebook, SMS, WhatsApp, CAP, etc.
- **Hardware Specific Devices**: Raspberry Pi, Android, Philips, video wall management, etc.

Ingestion, aggreg. → exploitation

- **IoT App Visual Programming, no coding**
  - **Data transformation**
  - **Integration, Interoperab.**
  - **Scripting Data Analytics**
  - **Data ingestion**
  - **Business logic**
- **Edge and Cloud**
- **MicroServices** data driven develop via visual language Node-RED





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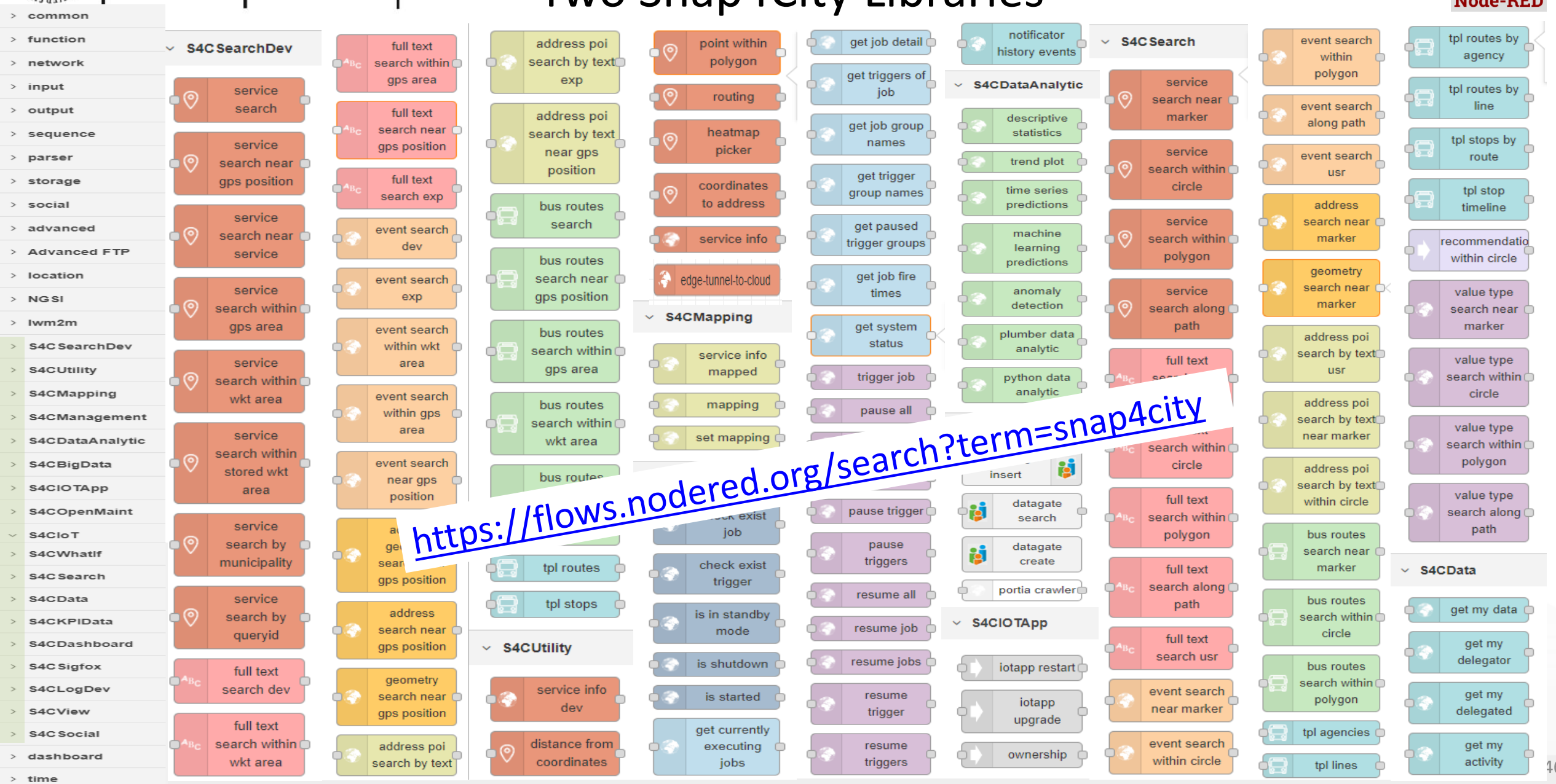
2024 collection
Two Snap4City Libraries

SNAP4CITY | Node-RED

https://flows.nodered.org/search?term=snap4city



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2024 collection

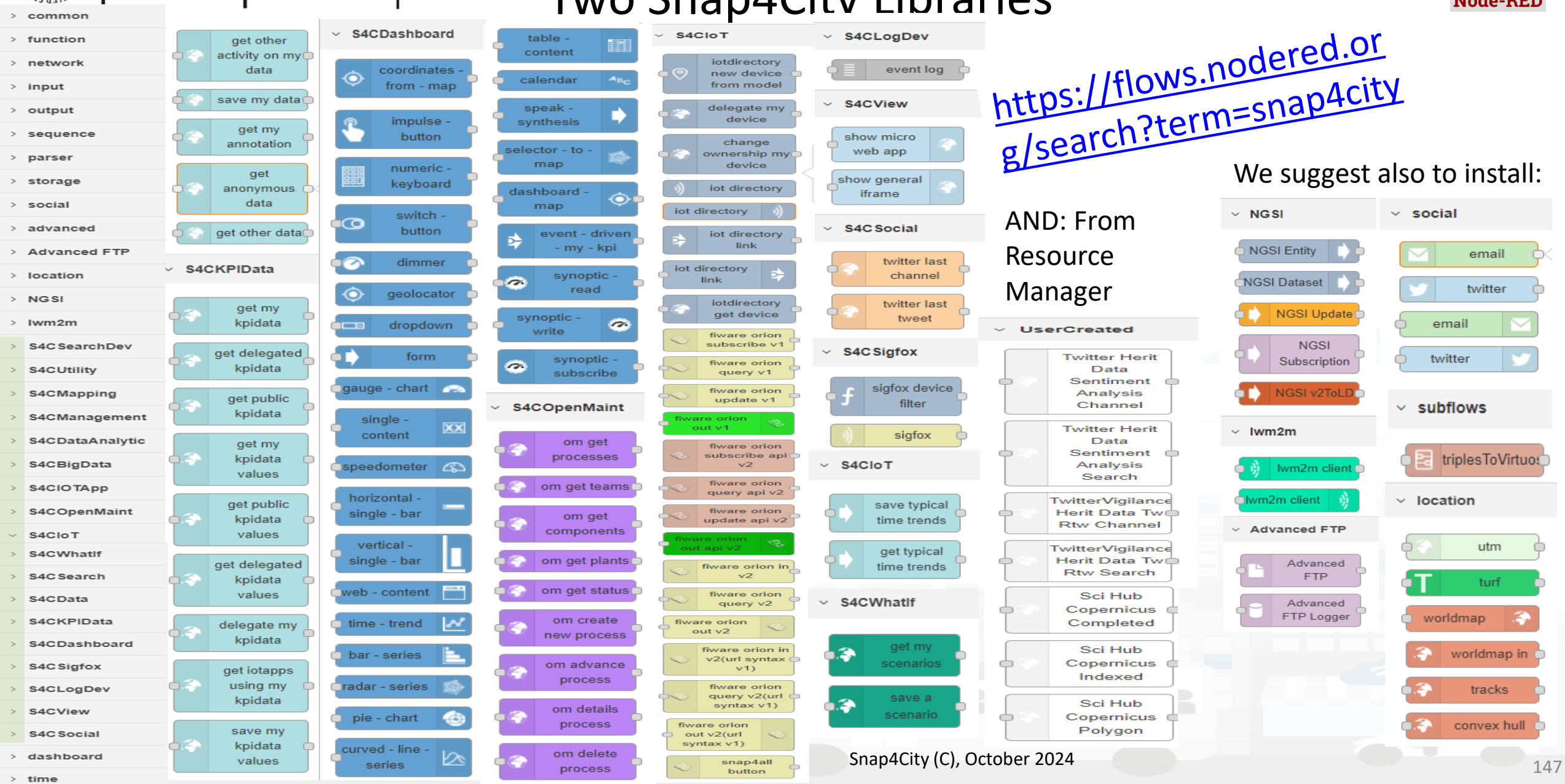
Two Snap4Citv Libraries

SNAP4CITY | Node-RED

https://flows.nodered.org/search?term=snap4city

We suggest also to install:

AND: From Resource Manager



IOT Applications

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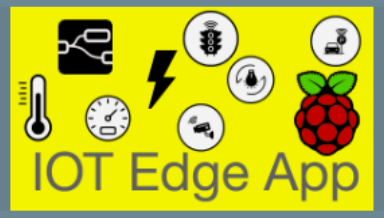
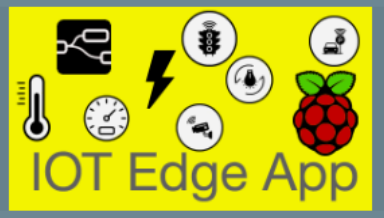


owner: badii

Management

2018-09-21T03:19



owner: panesi

Management

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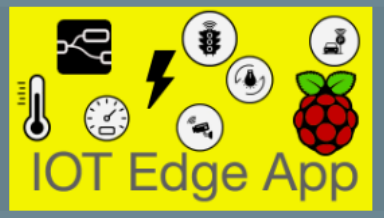

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Management

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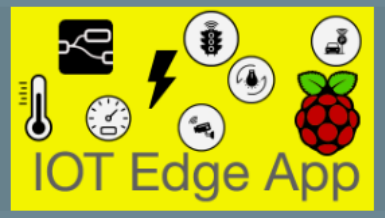

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Management

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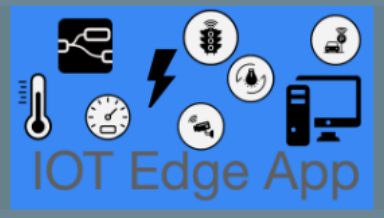


owner: semolarudy

Management

application

owner: tester5

Management

Bib APP

owner: semolarudy

Management

ChargingStations

owner: comunedashres

Management

Deprecated - SiiMobilityControlRoom

owner: badii

Management

SamsungGalaxyS4BarCode

owner: badii

Management

esercitazione

owner: tester2

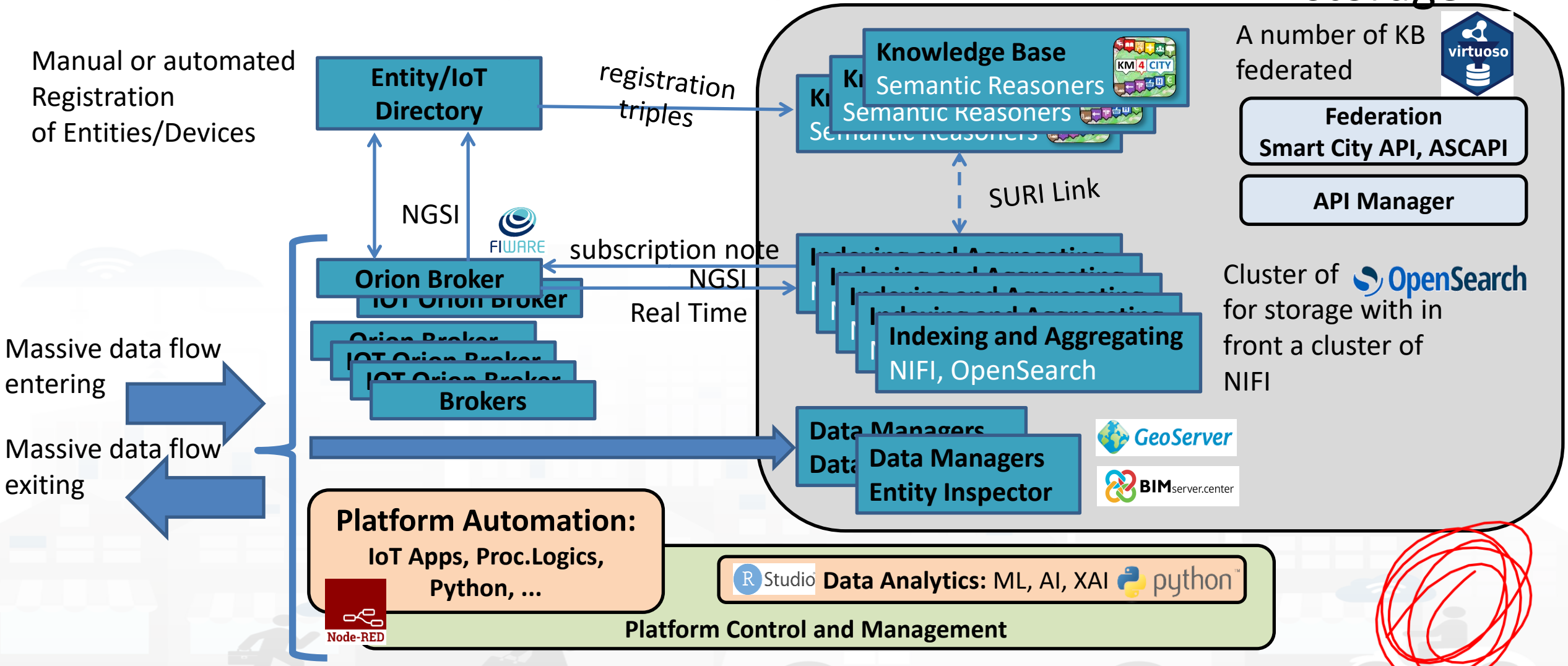
Management

Iot-App

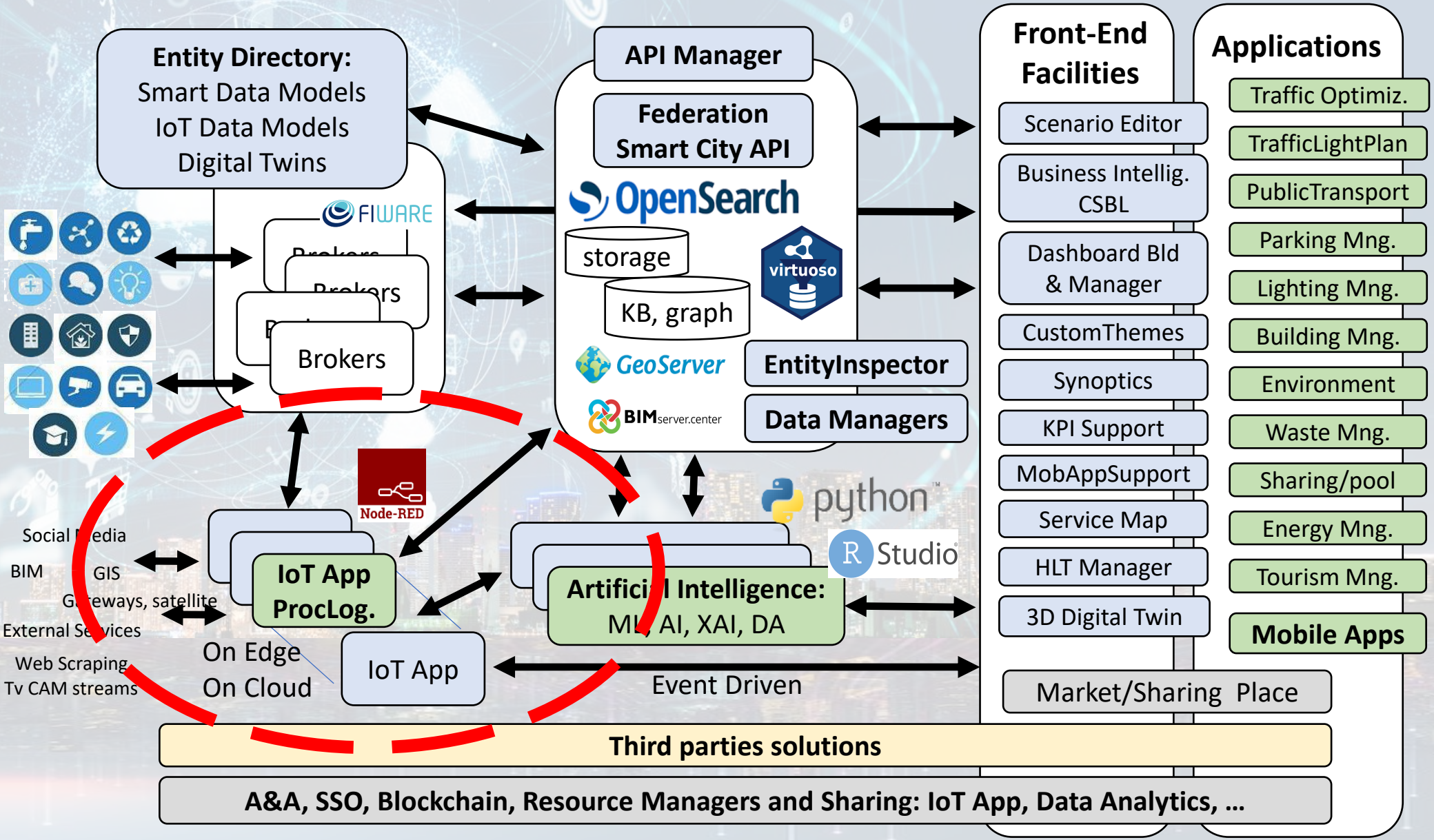
owner: tester14

Management

Snap4city Data Ingestion Diagram



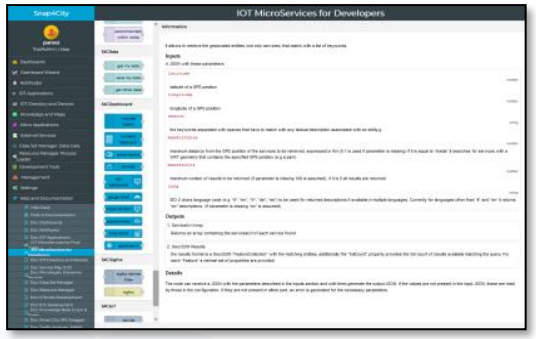
Technical Architecture



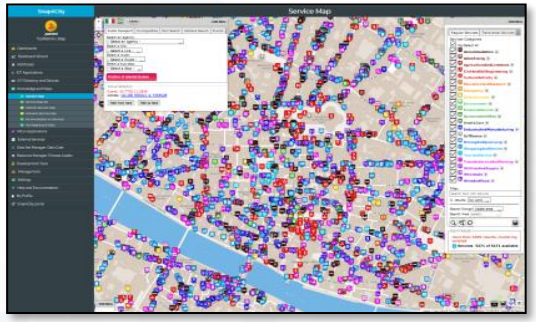
Proc.Logic / IoT App Development

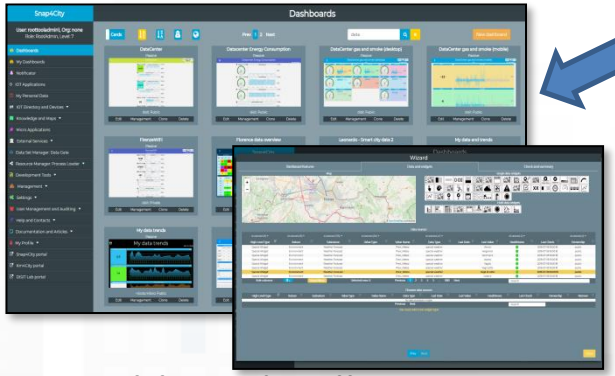
IOT Discovering

MicroServices collections



My IoT Applications





ServiceMap Discovery

Dashboard Collection, Editor and Wizard

IoT App. Editor

Generating IoT App With Dashboard

Sharing/saving reusing IoT App

Resource Manager

GitHub

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Paolo Nesi, paolo.nesi@unifi.it

Comparisons

https://www.snap4City.org **https://www.Km4City.org**

Market Solutions

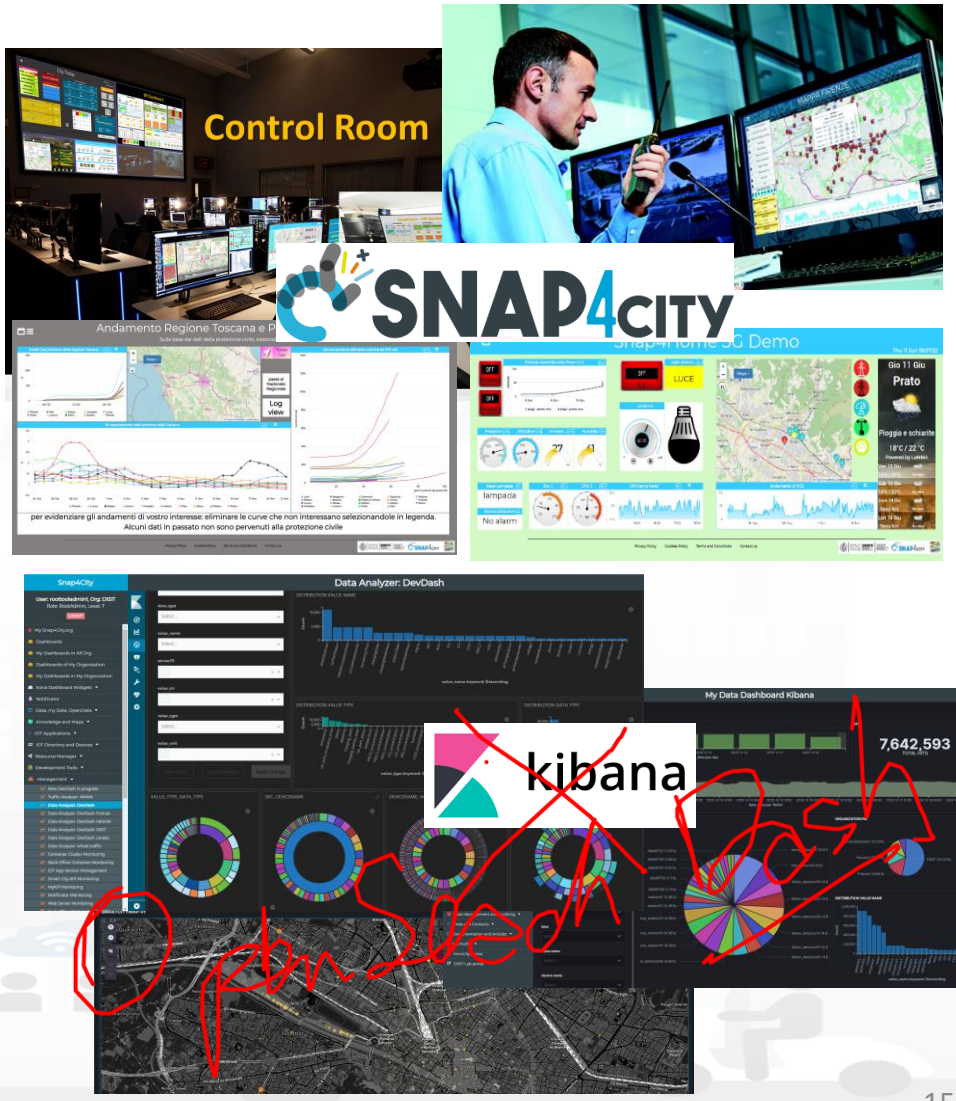
	Open Source end-to-end	Scalability IOT	Execution scalability	Visual Programming end-to-end applications	Advanced Smart City API, MicroServices Multi Domain Semantic Platform	External sevices via API	Standard based Modules and IOT, Open Devices Integrated	Community manmagement Resoruce Sharing	Referral data management	Security end-2-end	Dashboard H24/7	Falxible and easy dashboard creation	Multi-protocol on IOT
SNAP4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
KAA	Y	Y	Y	N	Y	N	Y	N/Y	Y	N	--	Y	Y	N	Y
AWS	N	Y	Y	N	N	N	Y	Y	N	Y	Y	Y	Y	(Y)	Limited
Azure IOT	N	Y	Y	(Y)	N	N	Y	Y	(Y)	Y	Y	Y	Y	(Y)	Limited
IOT IGNITE	Y	Y	N	Y	N	N	Y	N	N	N	--	N	Y	(Y)	MQTT
PTC ThingWorkx	N	Y	(Y)	Y	N	N	Y	Y	N	N	--	Y	Y	(Y)	Y
BEZIRK	Y	N	N	N	N	Y	--	Y	N	N	--	N	N	N	Y
Bosch IoT Suite	N	Y	(Y)	Y	Y	N	Y	Y	N	N	Y	Y	Y	(Y)	Y
FIWARE ref SC arc.	Y	(Y)	N	N	Y	N	N	Y	N	N	N	N	Y	N	Y
CISCO Jasper	N	Y	N	N	N	N	Y	N	--	--	Y	--	Y	--	N
IBM Watson IoT	(N)	Y	(Y)	Y	Y	Y	Y	Y	N	Y	(y)	Y	Y	Y	Y
Siemens MindSphere	N	Y	--	Y	N	N	N	Y	N	N	Y	N	Y	N	Y
Carriots	N	Y	--	N	N	N	Y	--	N	N	--	N	Y	Y	MQTT
Thingsboard	Y	Y	N	N	N	N	N	N	N	N	--	Y	Y	Y	(MQTT, CoAP, http)
IOT eclipse.org	Y	Y	N	N	N	N	Y	Y	N	N	N	N	N	N	Y
Google IOT	N	Y	Y	N	N	N	Y	N	N	N	N	Y	N	N	MQTT, HTTTP

Requirements on Broker Interoperability

Requirement	Snap4City	Google IoT Cloud	Azure IoT	AWS Amazon	IBM Watson	Siemens Mindsphere
Manage different kinds of IoT entities	Y	N	Y	(Y)	Y	Y
Connect External and Internal Brokers	Y	Y	Y	Y	Y	(Y)
Use any Data Model with any data type	Y	Y	(Y)	(Y)	Y	(Y)
Verify the correctness of IoT Messages of IoT Devices	Y	(Y)	(Y)	(Y)	(Y)	(Y)
Semantic Interoperability	Y	Y	Y	Y	Y	(Y)
Automatics deploy of Internal IoT Brokers	Y	N	N	N	N	Y
Register External Brokers	Y	N	N	N	N	N
Discover IoT Devices on IoT Brokers	Y	N	(Y)	N	(Y)	N
Easy management graphic interface to list and test IoT entities	Y	(Y)	(Y)	(Y)	(Y)	(Y)
Manage IoT Device Model and Device Data Type ownership and access grant	Y	Y	(Y)	Y	Y	Y

Two Main Lines for Dashboarding are present

- **Dashboard Builder of Snap4City**
  - For accessing and browsing data on: OpenDistro x ElasticSearch, Mongo, MySQL, Smart City API, Super and thus from federated Smart City API, etc.
  - Supports sensors/actuators: data driven data, maps in extended manner, data driven widgets, large collection of widgets, direct IoT Connections, custom widgets, animated PIN on maps, a large set of panel/widgets, etc.
  - Very simple to be used for control room, decision makers, situation rooms, operators, etc.
  - Very well integrated with IoT App, Custom widgets, animation, external services.
  - Very simple to be customized for non programmers since all the tools are visual.
  - Support for GDPR and deep control of access.
  - Can integrate Kibana/Grafana Views into a Widget
- **Kibana** (so called **DevDash**, **AMMA** and recently **My Dashboard (Dev) Kibana**), also accessible as Grafana
  - For accessing and browsing data on OpenDistro x ElasticSearch storage and other sources supported
  - No Support for real time event driven widgets/panels, actuators and synoptics, no sophisticated maps, etc.
  - Not simple for control room, decision makers, etc.
  - Not integrated with IoT App, Custom widgets, animation, external services.
  - Oriented to developers, complex production of custom views, etc.
  - Partial support of GDPR and deep control of access.



Snap4City Dashboard Builder (2023) vs Kibana/Grafana

Features	Snap4City Dashboard Builder	Kibana, Grafana
Large Collection of Widgets, also from D3 library	YES	Nothing
Custom Widgets SVG of any kind, full defined process for customization	YES	Nothing
Real time event driven widgets and data	YES	Nothing
Server/Client Side Business Logic for data transformation with visual programming: Node-RED	YES: visual/coding	coding
Maps with custom PIN, bubbles, animated and moving, etc.	YES	Nothing
Maps with paths, shapes, traffic flow, scenarios, routing, heatmaps, what-if, Origin Destination Matrix, …	YES	Nothing
Maps with Orthomaps from WFS, WMS, GIS connection, etc.	YES	Nothing
TV camera integration and selection	YES	Nothing
Widgets for business logic integration on real time: buttons, selector, switch, etc.	YES	Nothing
Kiviat, Spider net, Calendar (also any other D3 Widgets)	YES	Nothing
Typical Time Trends: day hours, month week, month days, …..	YES	Nothing
Time Trend Compare: day, week, month, year	YES	Nothing
Selectors/Menus: text, icons, etc., also in connection with IOT APP, Node-RED	YES	Nothing
Full control of graphic layout, font, colours, refresh per widget, etc.	YES	Nothing
Iframe integration of third party widgets and web pages, nesting dashboards, embedding Kibana	YES	Nothing
Connection among multiple Dashboards and Widgets	YES	Nothing
Synchronization with Video Wall, and Operators Views	YES	Nothing
Multiseries, bar lines, charts, pie, donut, simple selectors, trends, etc., also from business logic	YES	Limited
Single content, string, html, any data, etc.	YES	Limited
Special widgets: Weather forecast, civil protection, road plates, Twitter, SVG, etc…	YES	Nothing
Digital Twin Local (BIM) and Global (3D city representation) with 3D traffic, Heatmaps, Devices, …	YES	Nothing
Faceted search	YES: selectors, forms, buttons	YES

Functional: FIWARE ref arc wrt Snap4City solutions

	FIWARE ref arc smart city	Snap4City
Multiple Protocols: IoT, Databases, etc..	10 on IOT, Limited on databases, etc.	More than 200, very very wide
Large set of high level types: maps, trends, heatmaps, traffic, trajectories, scenarios,…	No	Yes:
Integration with workflows, BPM	Not Supported	Yes: bidirectional
Integration and Modeling Digital Twin BIM	Not Supported	Yes: bidirectional
Integration with GIS: WFS, WMS	Not fully supported	Yes: bidirectional
Integration with Heatmaps and Satellite	Partially, not calibrated	Yes: fully; calibrate and multiple versions, animations
Integration with Satellite	not supported	Yes: fully
Smart City API	no	Yes
Open Data Management	Partial with CKAN	Yes, Fully automated with CKAN
Federation of platforms	Partial on brokers	Full on Brokers and Knowledge base and API
Semantic model and queries	with NGSI-LD in the future	Yes since 2013
Multiple kinds of IoT Brokers	No, only agents	Yes: NGSI, COAP, AMQP, MQTT, SigFOX, etc.
Data Model	Smart Data Models	Smart Data Models, IoT Device Models
Complex data Model	Not supported	Heatmap, traffic flow, ODM, 3D models, TV Cam, etc.

Interoperability
Openess

Functional: FIWARE refarc. wrt Snap4City solutions

	FIWARE ref arc smart city	Snap4City
Data Transformation	Coding	Yes: IOT App, Node.JS, Visual Programming, scalable
Data Analytics	No	Yes
on line development	No, limited	Yes: Rstudio, Python, Tensor Flow, MapReduce, etc.
Dashboard on data	Grafana no LDAP	Yes: Dashboard Builder, OS Dash with GDPR, LDA
Dashboard Widgets	Limited, no custom, coding needed	Yes: A wide range including custom widgets, secure compliant, animations, configuration, also open to new development
Real Time end-to-end from Dashboards to any other channel, event driven	No, very limited	Yes, fully supported
Multi Data Map	Limited with non OS	Very extensive, with multiple widgets and sync
MicroApplications	No	Yes
Auditing, Assessment, accounting	No, no, no	Yes, Yes, Yes
Multitenacy on data management	No only on broker	Yes: on Broker, on data management, on dashboards, etc..
Living Lab for creating/managing communities/groups	Not supported	Yes: provided in the open source
Report generation/management	No	Yes

Process Graphics Manag.

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

Plataforma	Lenguajes	Recursos	APIs	Despliegue	Observaciones
PROMENADE	Java	Kubernetes, Apache Kafka, Flink	RESTful, WebSockets	Contenedores	Código no disponible en el momento de la prueba
Mi-FIWARE	Java, Node.js	FIWARE	RESTful, NGSI, SocketIO	Contenedores	**Seleccionada para Evaluación**
VirIoT	Python	Docker, Kubernetes, Kafka	RESTful, NGSI	Contenedores	**Seleccionada para Evaluación**
ITrade	Java, JavaScript	Kafka, Pulsar	RESTful	Contenedores	Pocos proyectos, enfocada en IoT solamente
Snap4City	Python, Java, JavaScript, PHP, Node-RED	Kibana, Km4City, FIWARE	RESTful, WebSockets, NGSI	Contenedores, VMs	**Seleccionada para Evaluación**
Sentilo	Java, JavaScript	–	RESTful	VMs	Enfoque en gestión de sensores
OpenRemote	Java, Python, C++	UI	RESTful	Contenedores	Pocas implementaciones
Sapparchi	Java, Ruby	Nginx, Kafka, otros	RESTful	Contenedores, VMs	Código no disponible en el momento de la prueba

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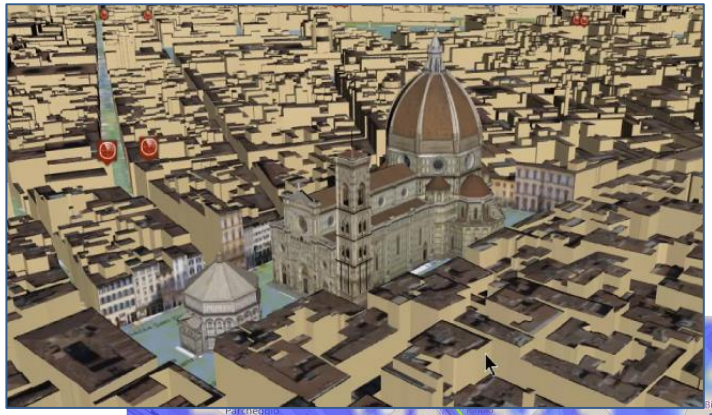
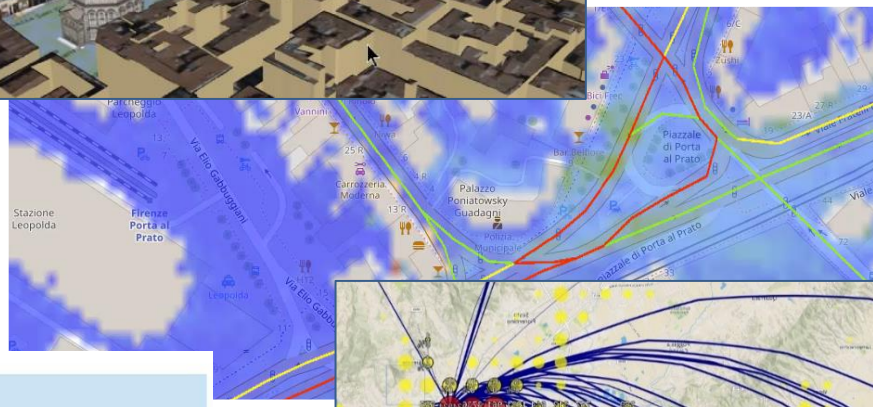
From Operation to planning

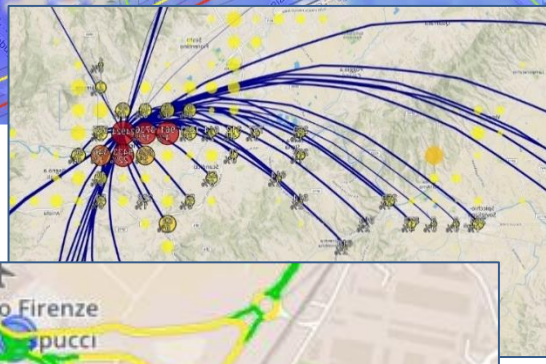
https://www.snap4City.org **https://www.Km4City.org**

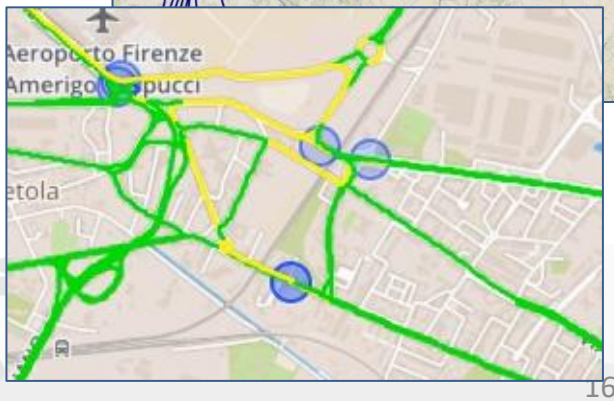
Main Tasks

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions data from the field and KPI
  - Anomaly detection
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range**
  - Optimisation: Prescriptions, suggestions
  - Risk assessment
  - What-if analysis on scenarios
    - Simulation and predictions
  - Resilience
- **Be ready for Unexpected Unknows**



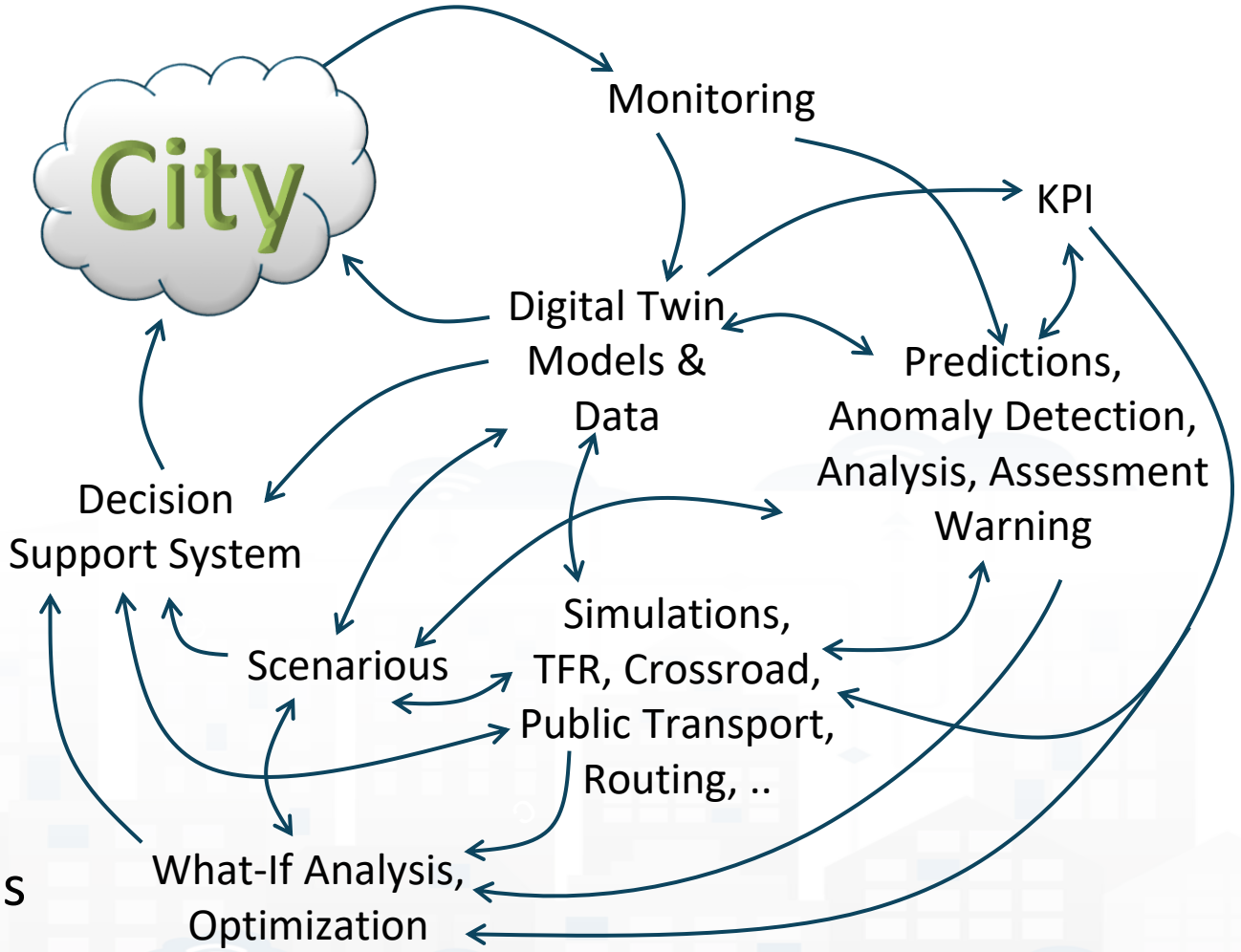


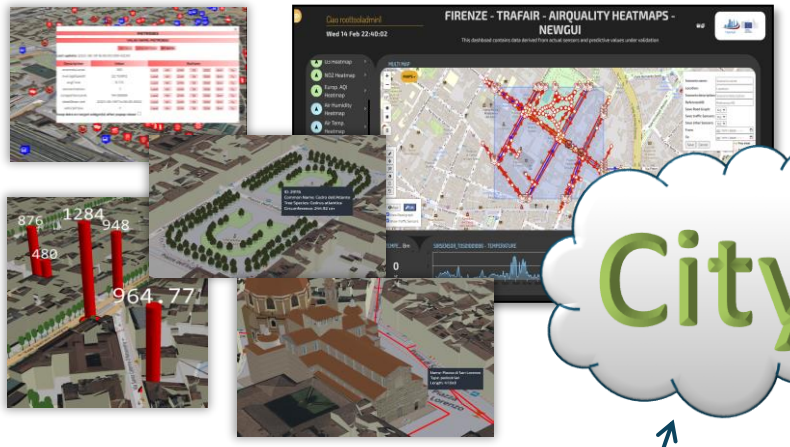




Main tasks

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Predictions vs KPI
  - Anomaly detection
  - Neuro-Symbolic analysis
  - Risk assessment
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range, micro/macro**
  - Simulation & optimization
  - Generative AI Prescriptions, scenarios
  - Resilience to Unexpected unknows
  - What-if analysis wrt scenarios





City

Monitoring

KPI

Digital Twin Models & Data

Predictions, Anomaly Detection, Analysis, Assessment Warning

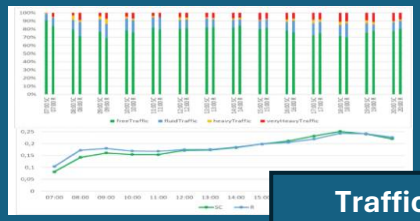
Decision Support System

Scenarious

Simulations, TFR, Crossroad, Public Transport, Routing, ..

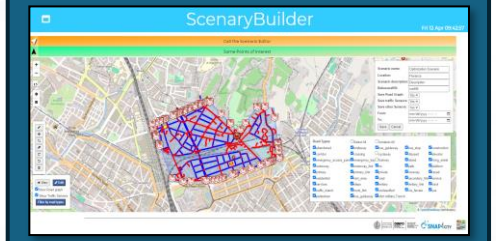
What-If Analysis, Optimization

KPI, Predictions, ...



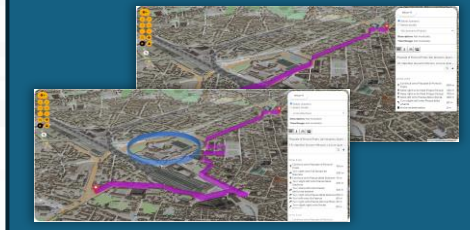
Traffic Reconstruction

Scenario Editor

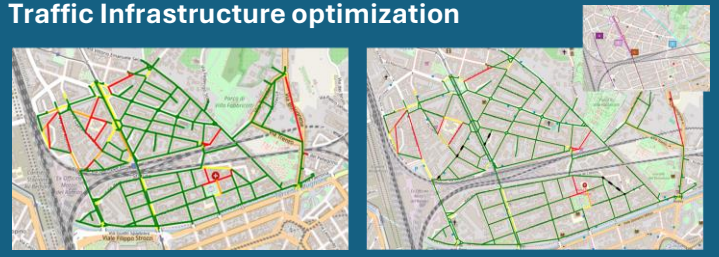


Traffic Light Plan optimization

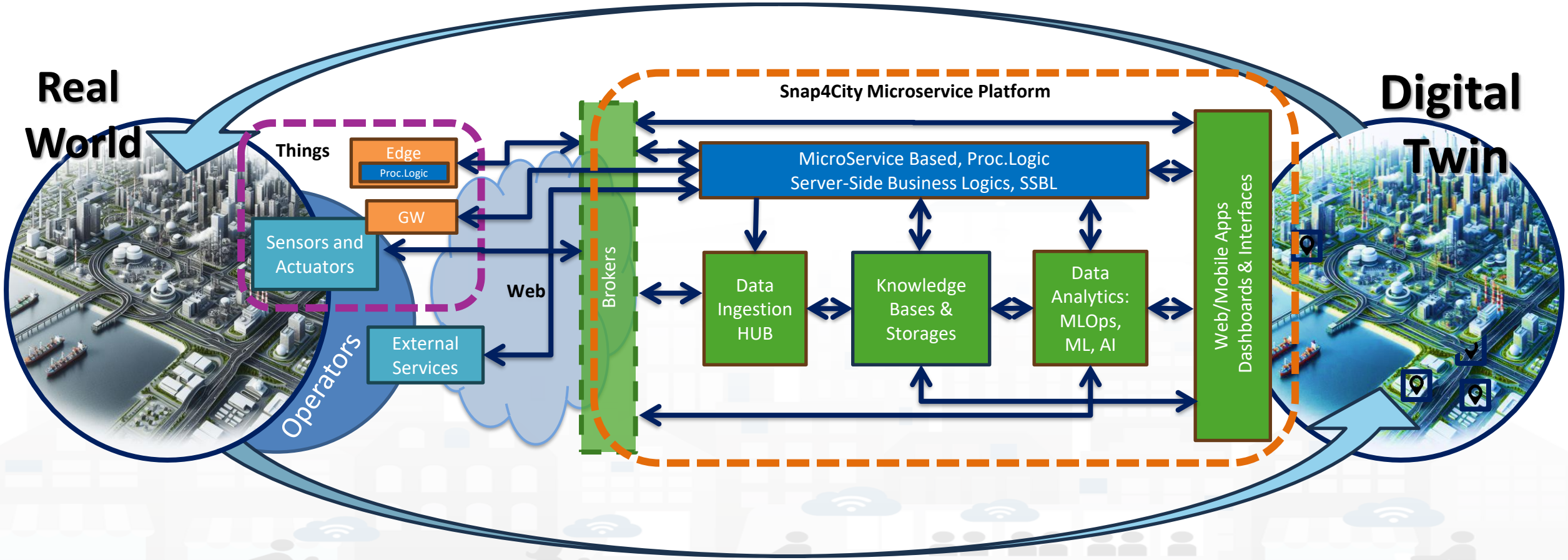
Routing / Dynamic Routing



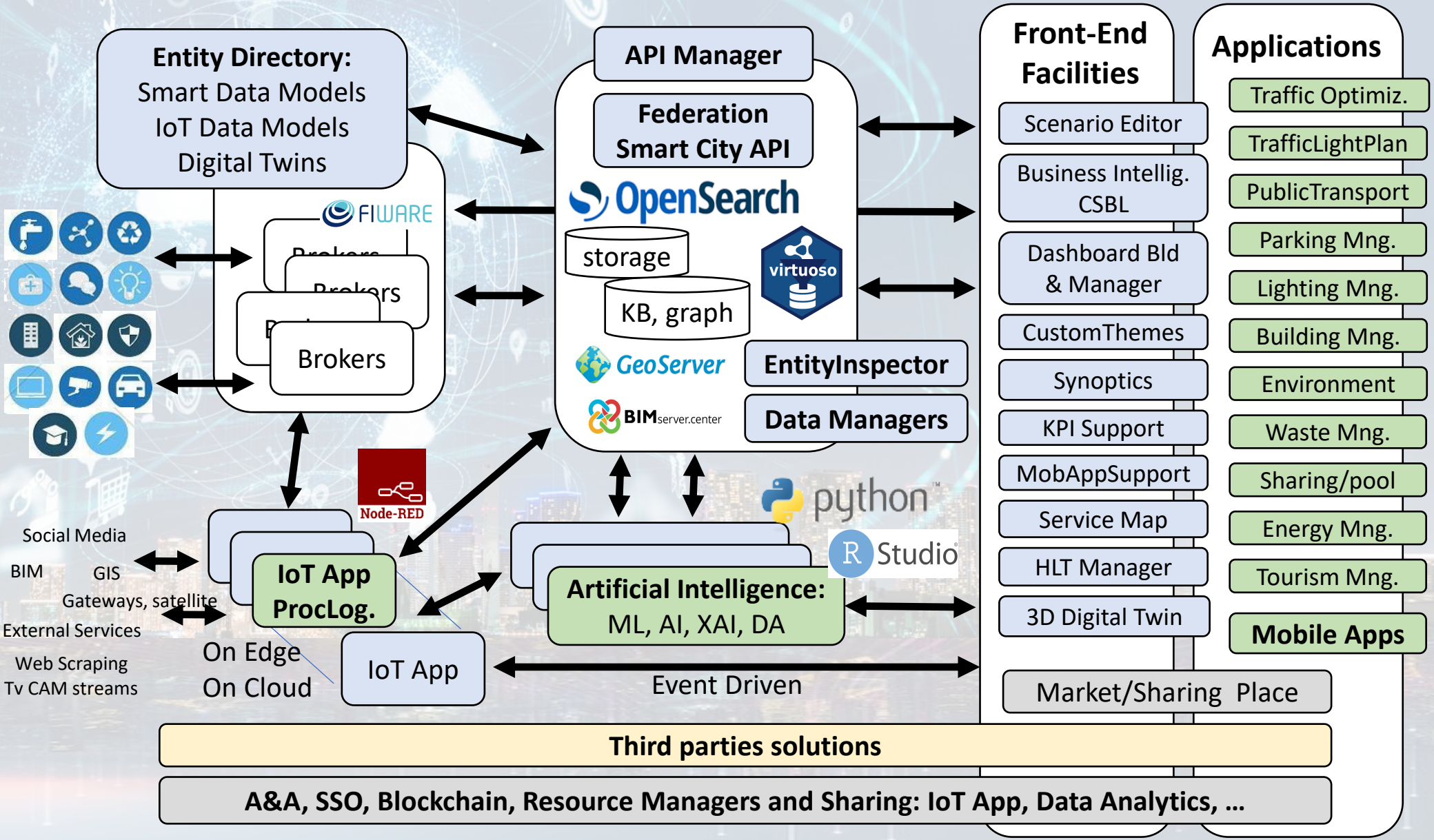
Traffic Infrastructure optimization



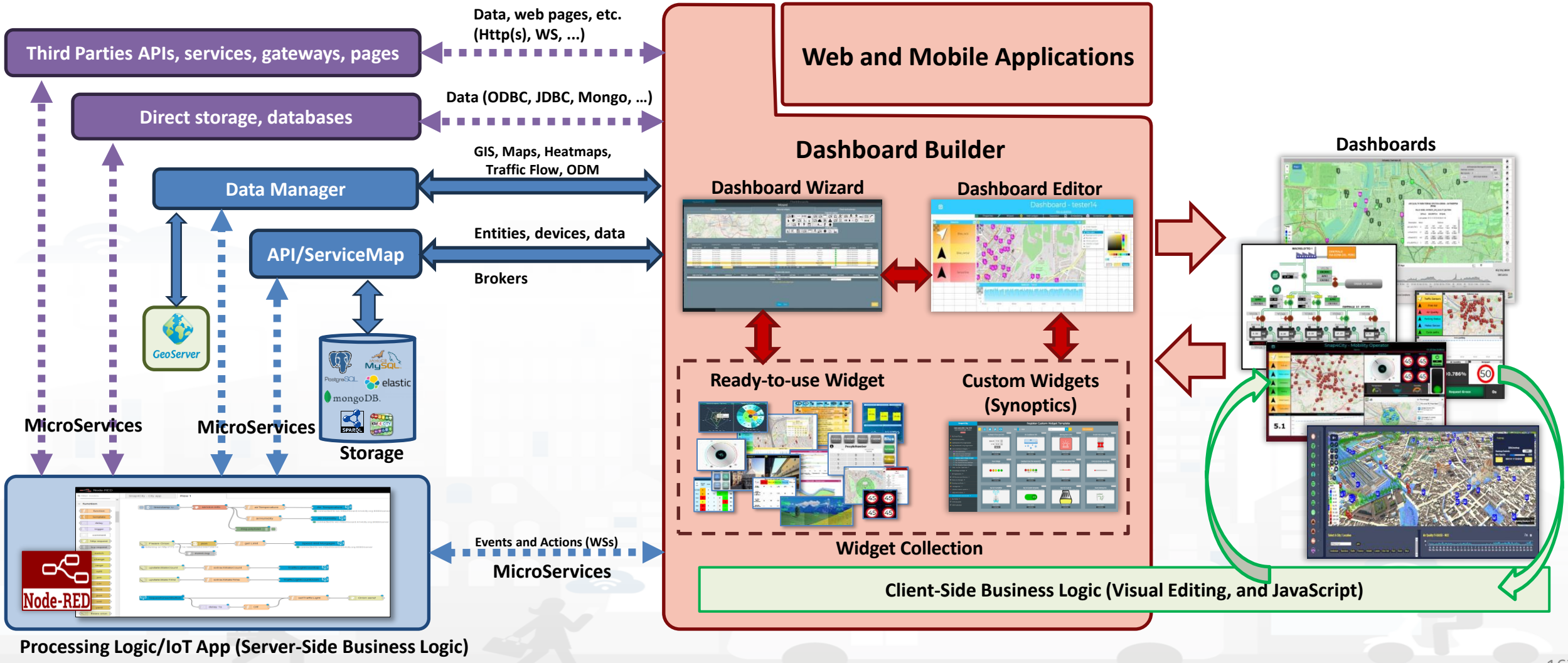
Digital Twin Development Platform

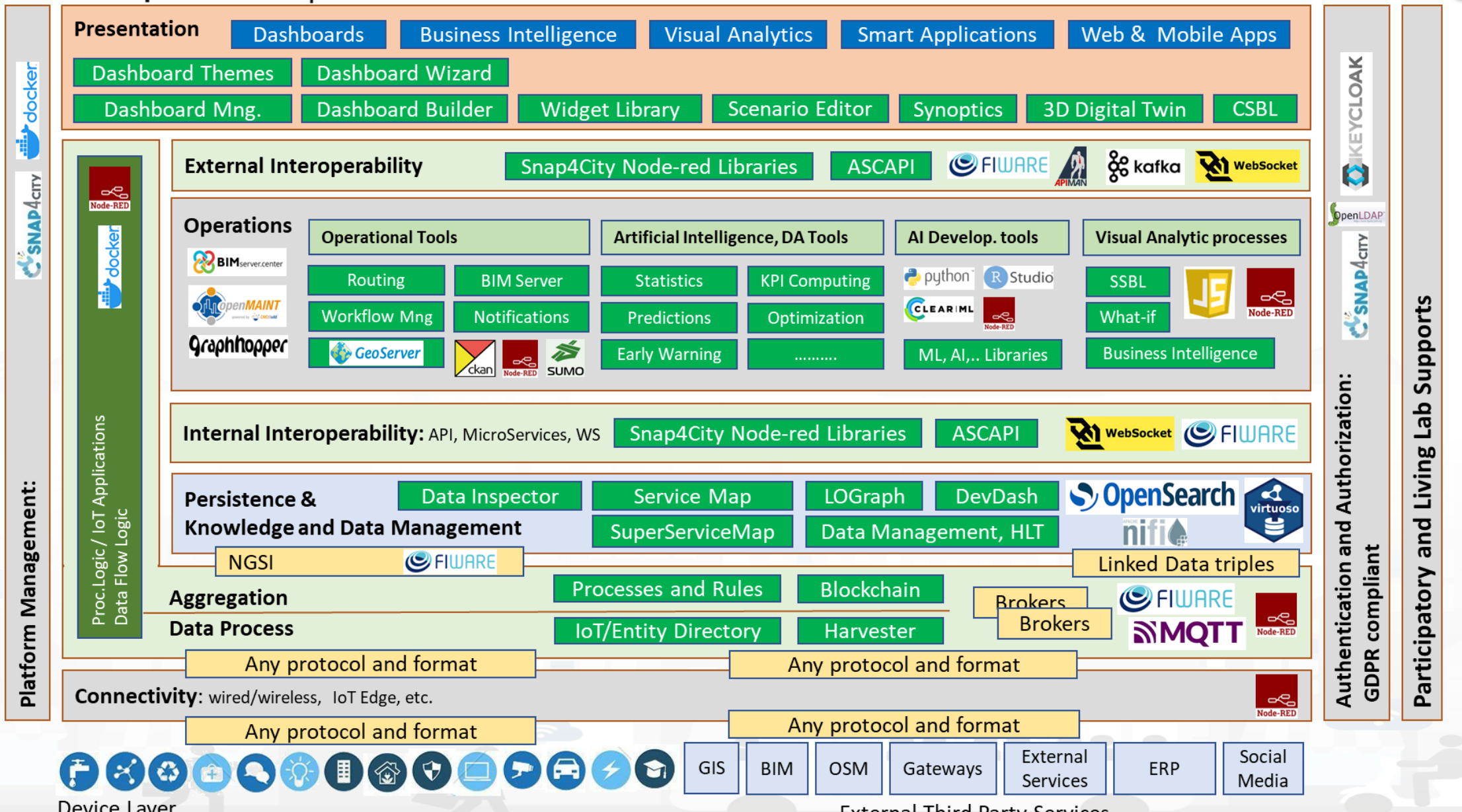


Technical Architecture



How the Dashboards / Apps Exchange data (2024/8)




Platform Management:
Presentation
Dashboards
Business Intelligence
Visual Analytics
Smart Applications
Web & Mobile Apps
Dashboard Themes
Dashboard Wizard
Dashboard Mng.
Dashboard Builder
Widget Library
Scenario Editor
Synoptics
3D Digital Twin
CSBL
External Interoperability
Snap4City Node-red Libraries
ASCAPI
Operations
Operational Tools
Routing
BIM Server
Workflow Mng
Notifications
Artificial Intelligence, DA Tools
Statistics
KPI Computing
Predictions
Optimization
Early Warning
AI Develop. tools
ML, AI,.. Libraries
Visual Analytic processes
SSBL
What-if
Business Intelligence
Internal Interoperability: API, MicroServices, WS
Snap4City Node-red Libraries
ASCAPI
Persistence & Knowledge and Data Management
Data Inspector
Service Map
LOGraph
DevDash
SuperServiceMap
Data Management, HLT
NGSI
Linked Data triples
Aggregation
Data Process
Processes and Rules
Blockchain
IoT/Entity Directory
Harvester
Brokers
Brokers
Proc.Logic / IoT Applications Data Flow Logic
Any protocol and format
Any protocol and format
Connectivity: wired/wireless, IoT Edge, etc.
Any protocol and format
Any protocol and format
Device Layer
GIS
BIM
OSM
Gateways
External Services
ERP
Social Media
External Third Party Services
Authentication and Authorization: GDPR compliant
Participatory and Living Lab Supports

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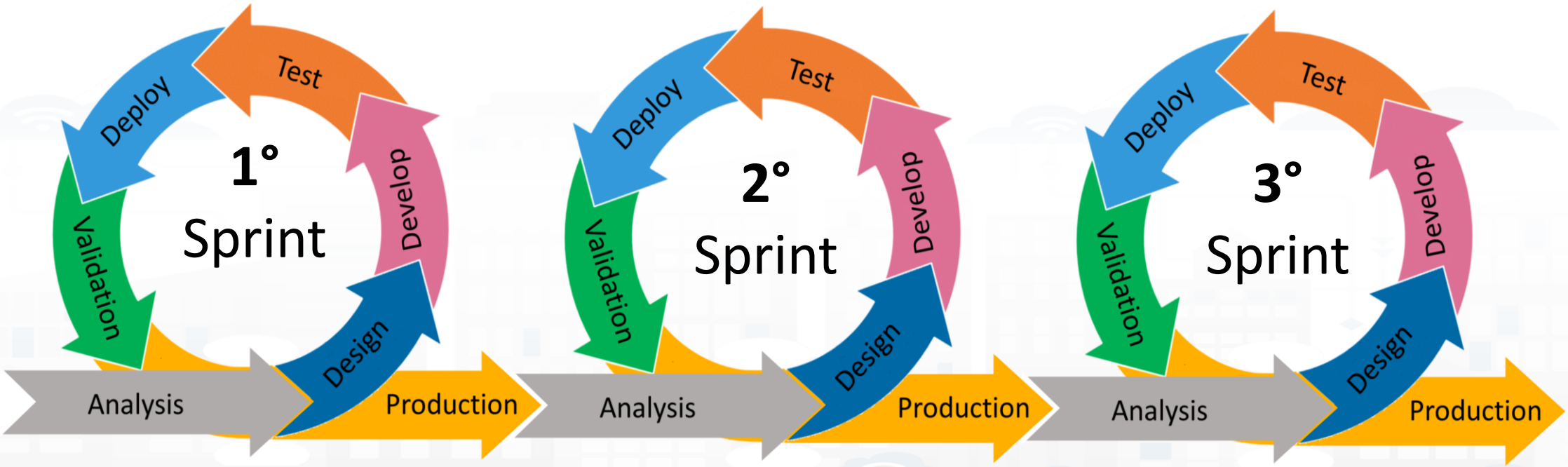
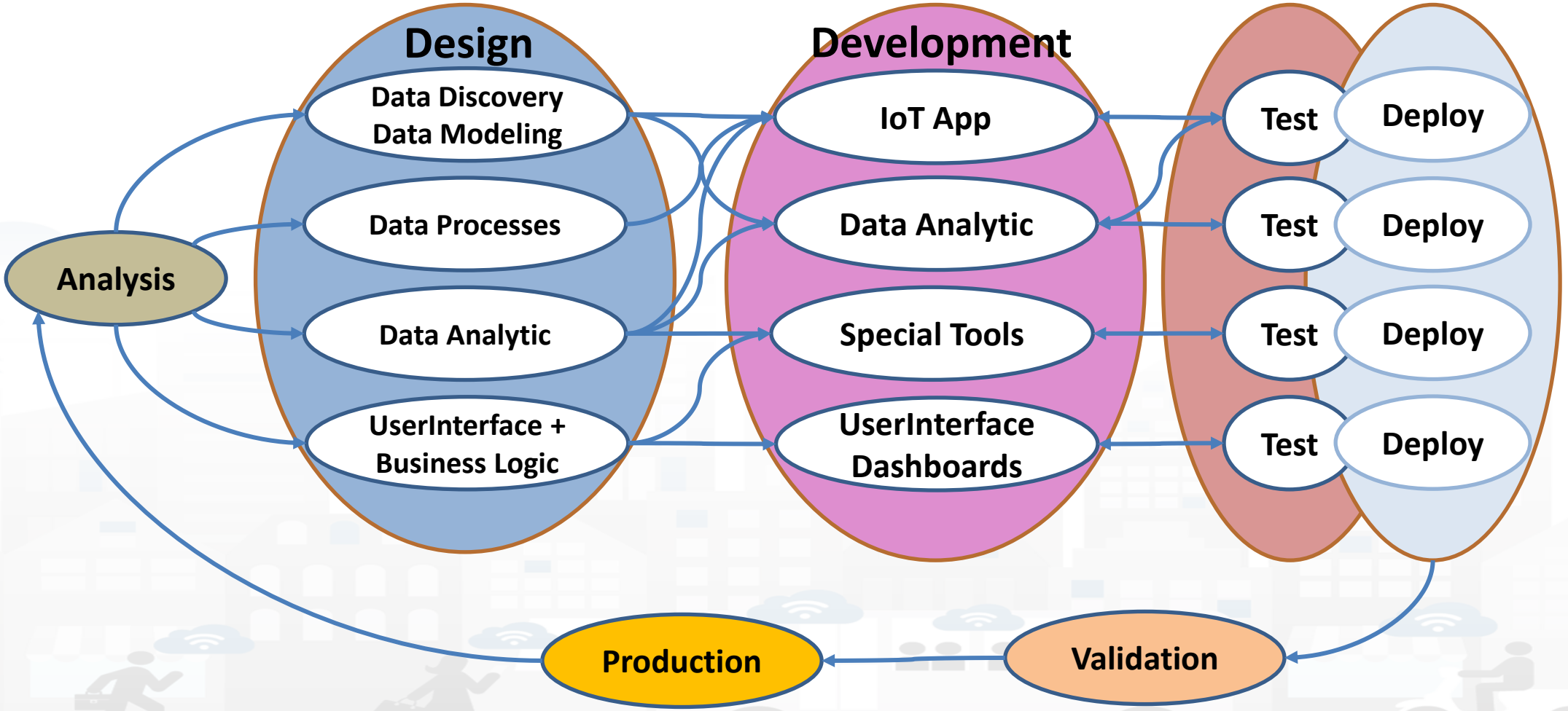
Development Life Cycle

https://www.snap4City.org **https://www.Km4City.org**

Development Life Cycle Smart Solutions

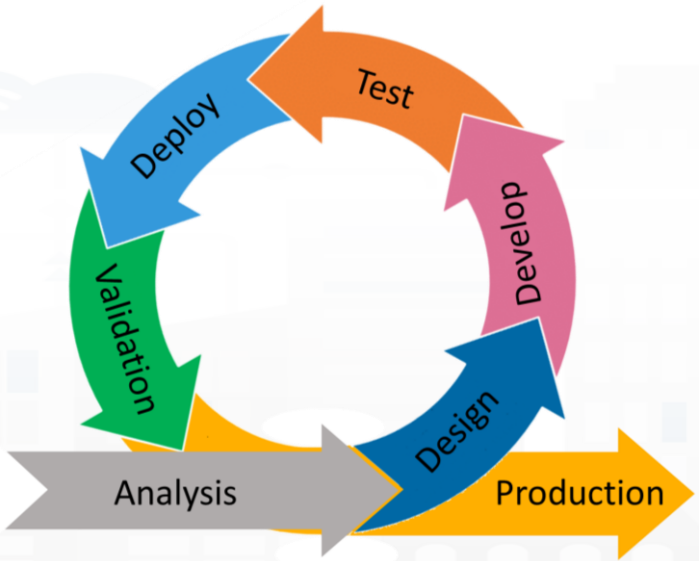


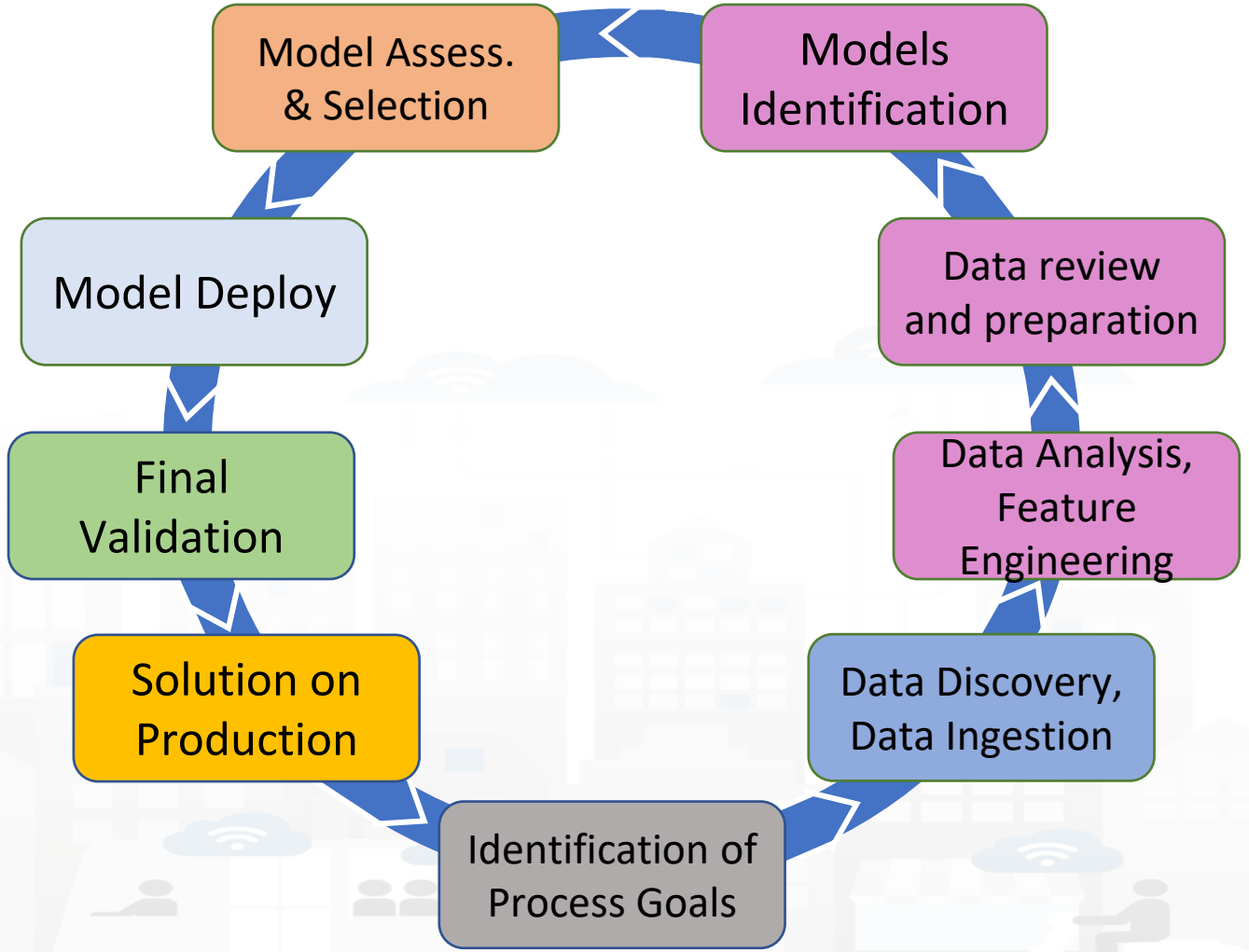
Development Life Cycle Smart Solutions



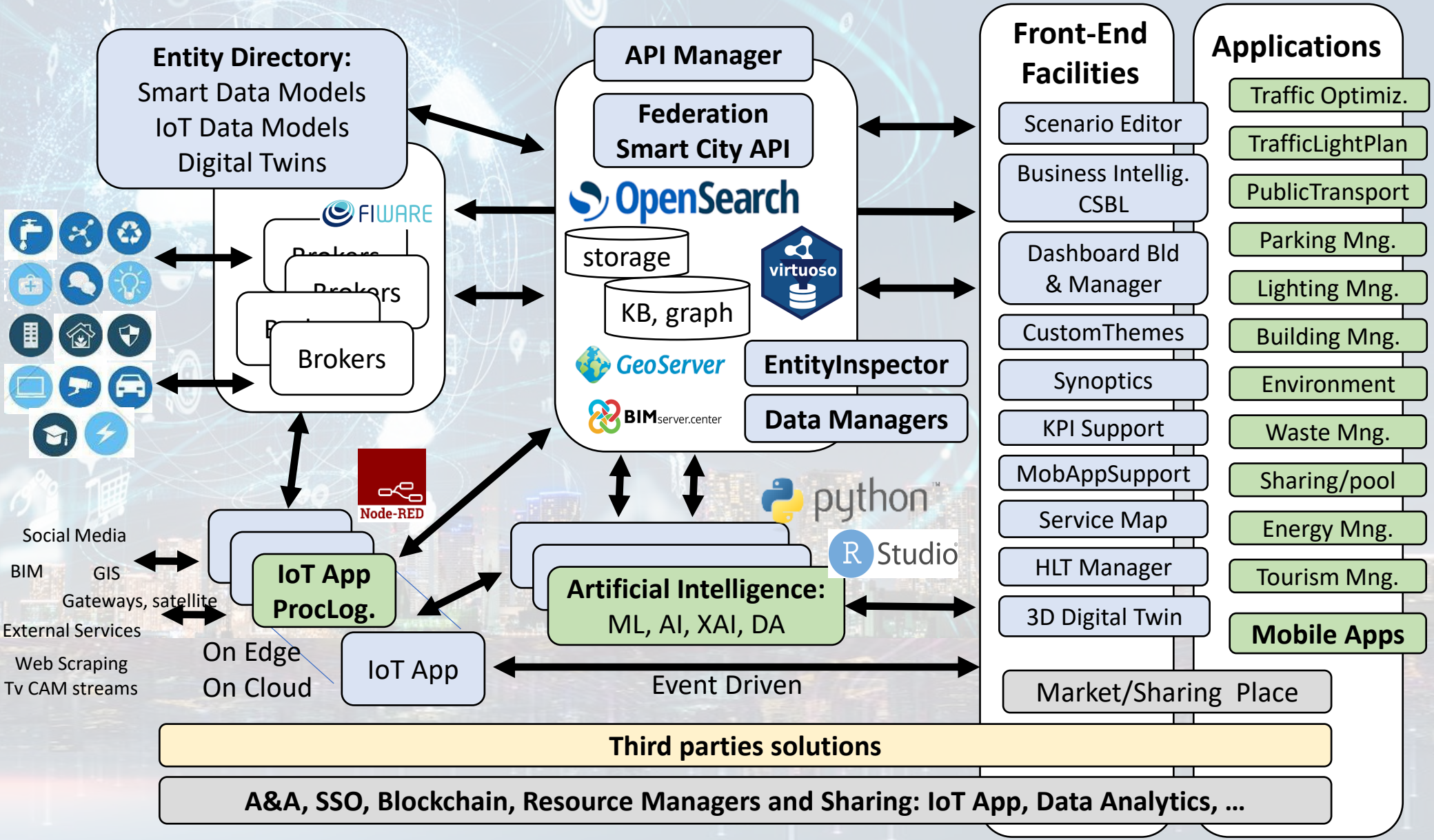
Data Analytics Development Life Cycle

- Detailed development process

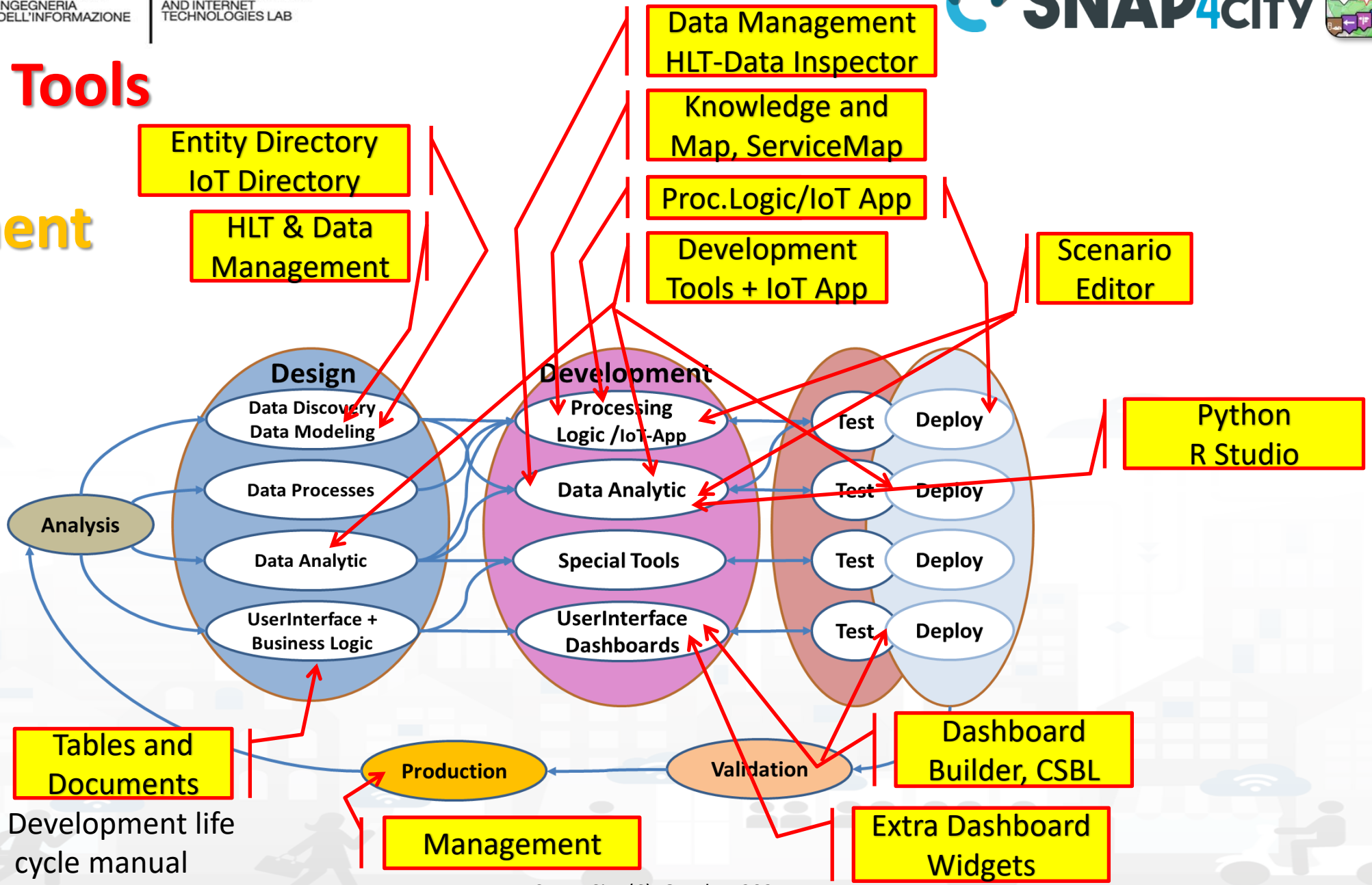




Technical Architecture

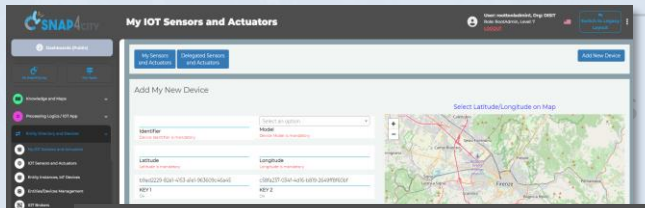


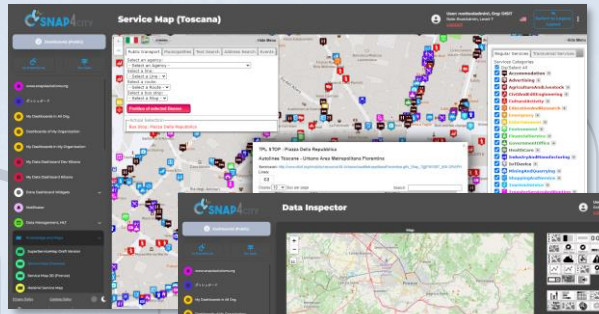
Snap4City Tools vs Development Life Cycle

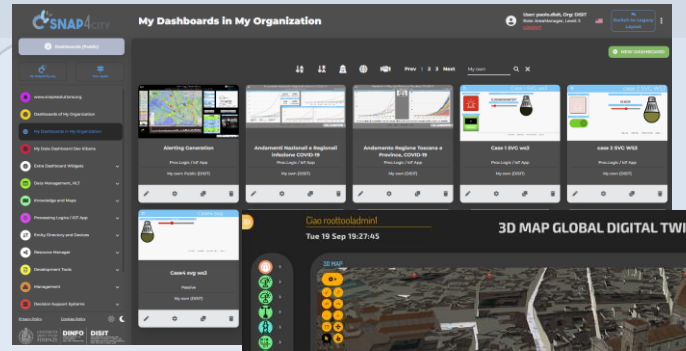


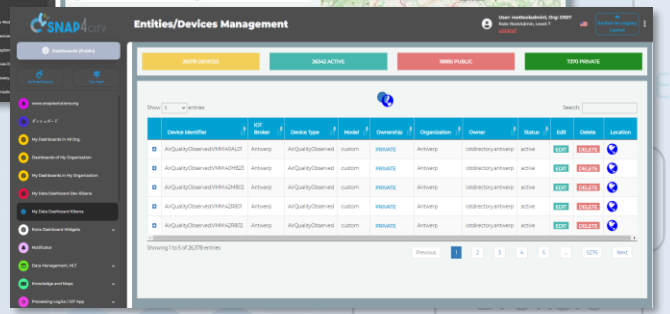
Development life cycle manual

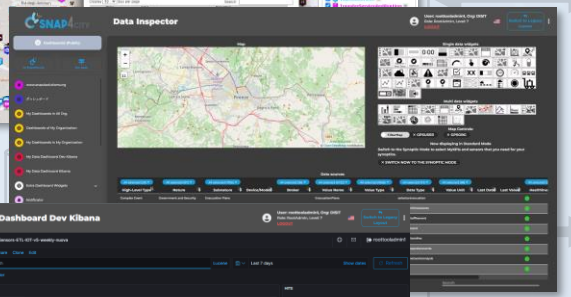
Visual Development Tools

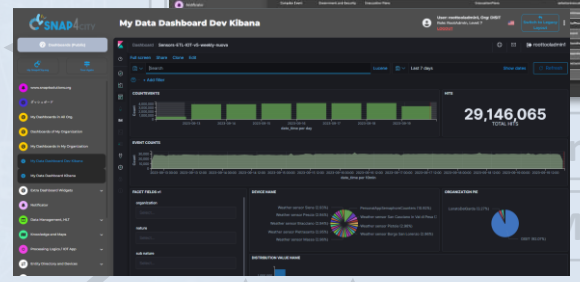


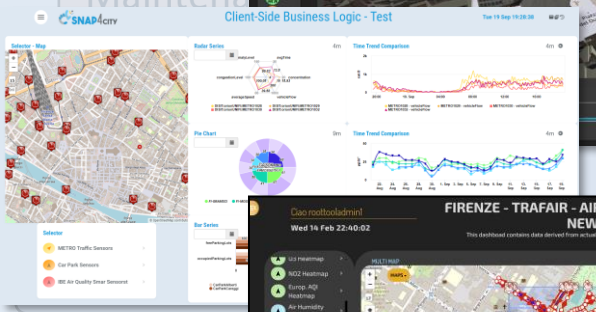


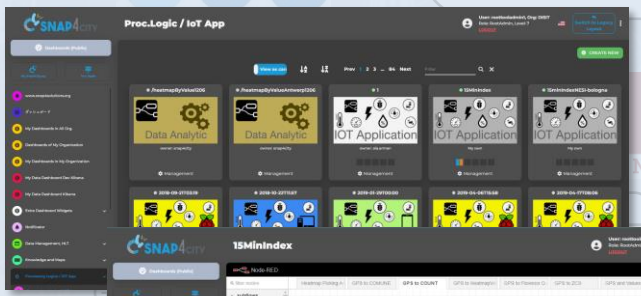


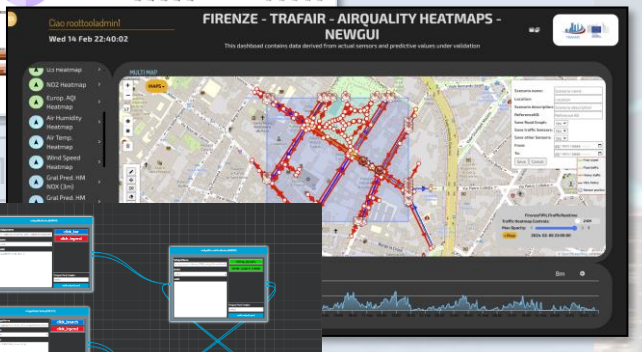


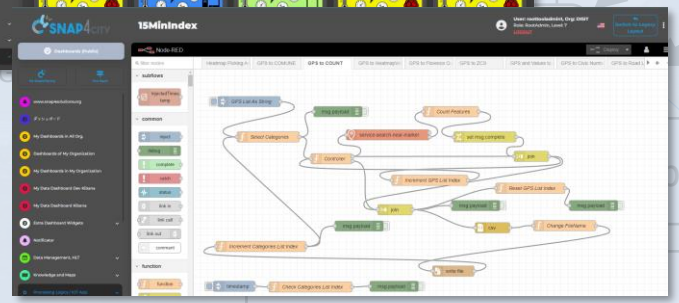


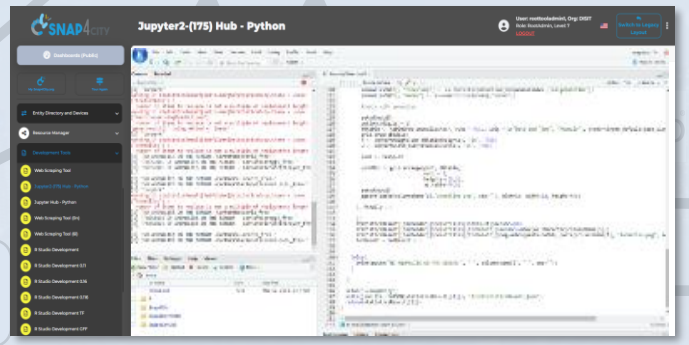


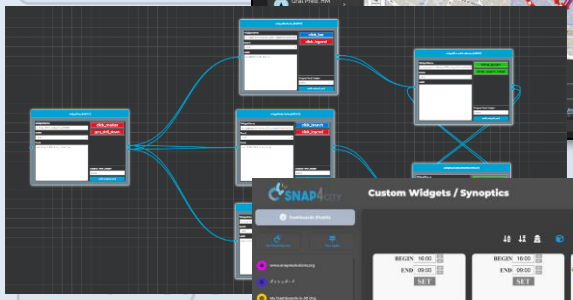












Maintena

nspector

Managers

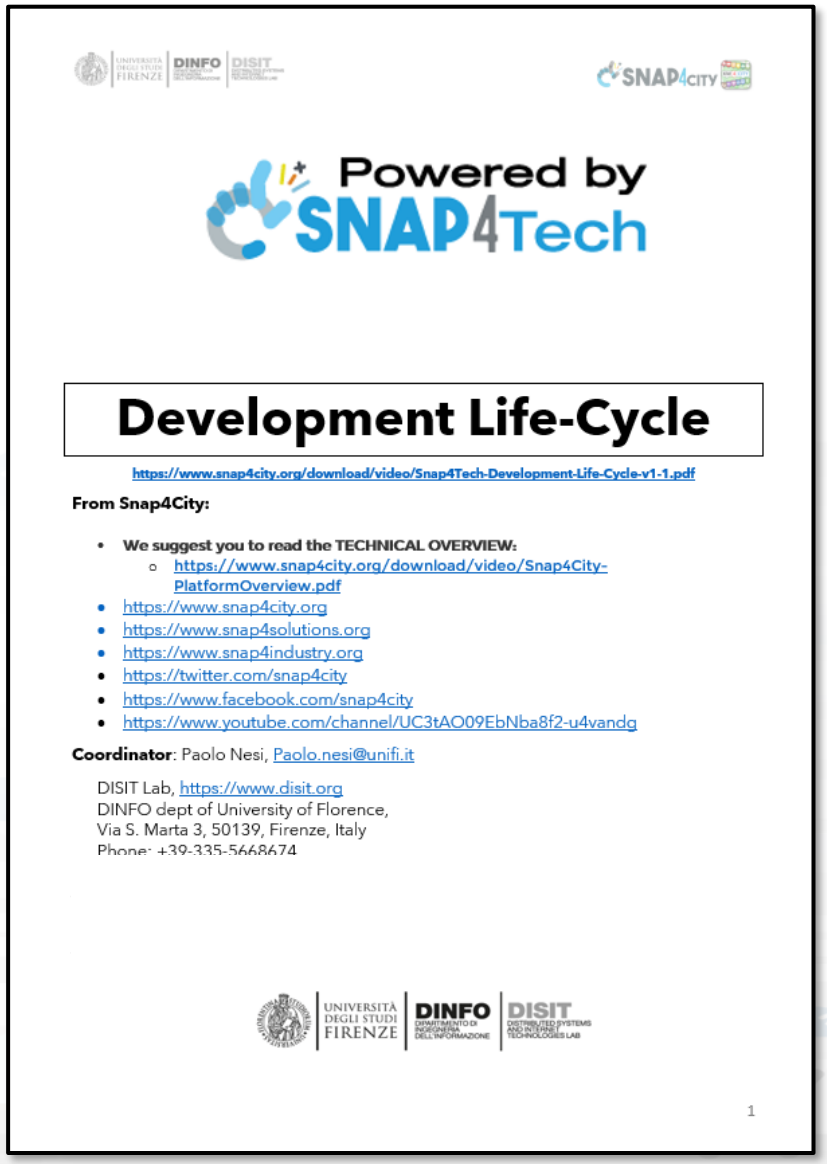
Service M

Node-RED

Third parties solutions

A&A, SSO, Blockchain, Resource Managers and Sharing: IoT App, Data Analytics

Development



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Development Life-Cycle

https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle-v1-1.pdf

From Snap4City:

- **We suggest you to read the TECHNICAL OVERVIEW:**
  - https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf
- https://www.snap4city.org
- https://www.snap4solutions.org
- https://www.snap4industry.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

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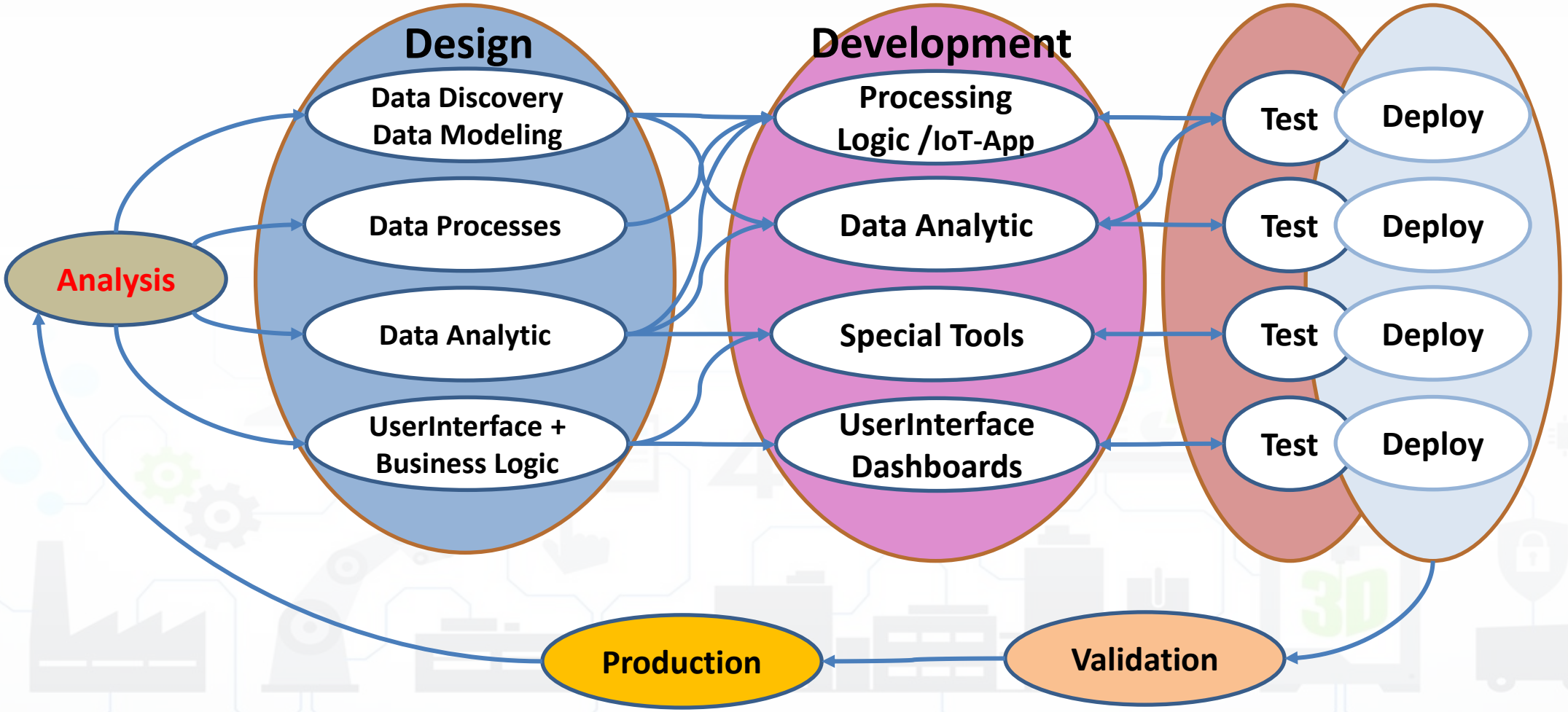
https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf

Development Life Cycle Smart Solutions

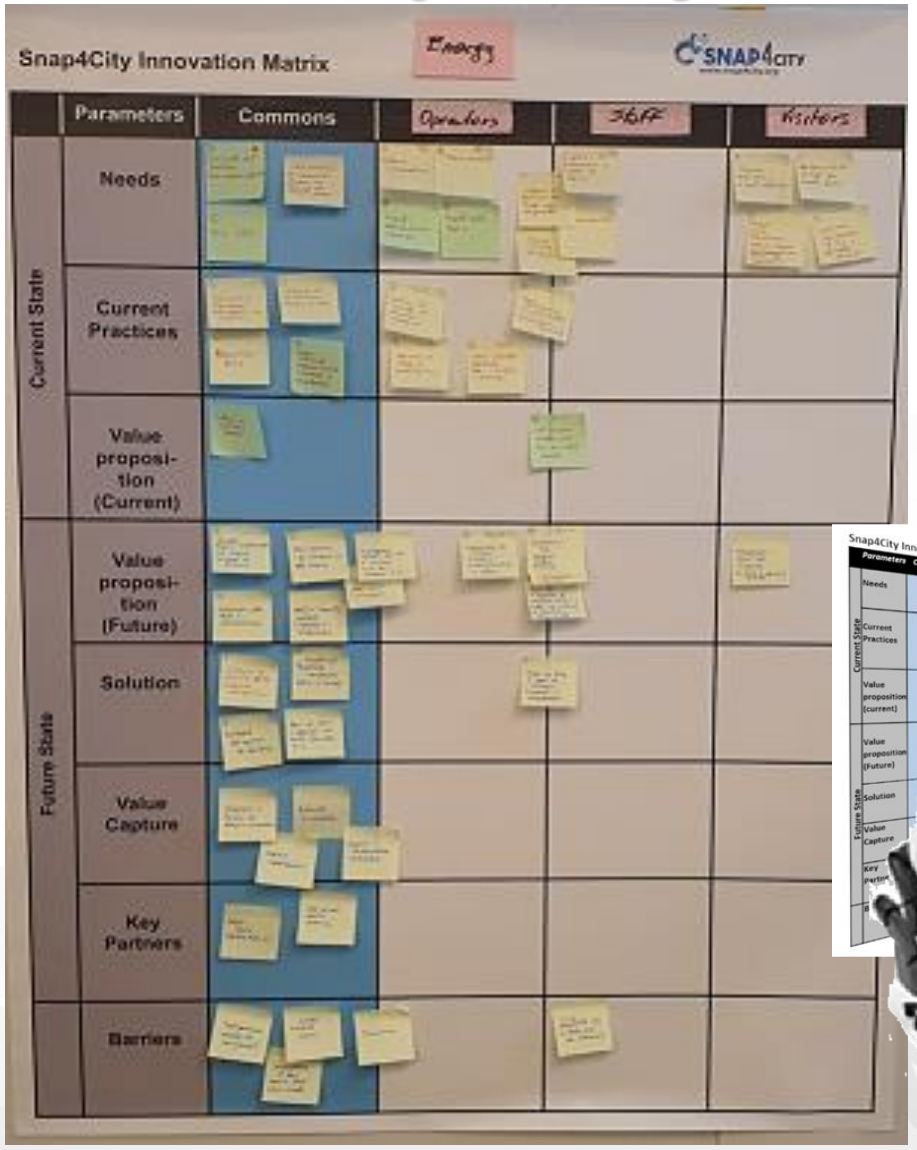


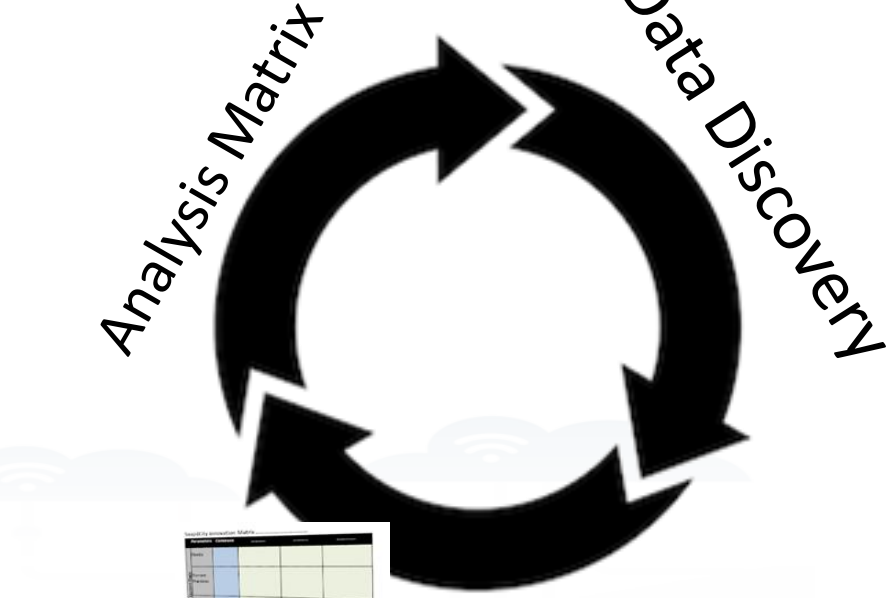
Analysis 1/2

- **Performing workshops:** Innovation Matrix by domain
- **Entity Identification**: which is the **Dictionary**
  - **Actors and their profiles (as Entity Models, IoT Device Model):** User, Operator, final user, ict expert, decision maker, doctors, driver, etc.
  - **entities and their digital counterpart (as Entity Models, IoT Device Model)** for: Vehicle, Analysis, Server, Client, Mobile App, parking area, etc.
  - **Entity Instances / IoT Devices which are instances of the models** as: City user XX, Control Room Operator, Doctor Rossi, Cop 3726, Car FI796HG, IoT Device XY, Trip 34, Patient Health Record for Robert, etc.
  - **Modules or Tools** of Third party or legacy tools: they are applications, servers, IoT Edge subsystems, well known services for data providing, gateway, brokers, etc., which should interact some how with your solutions. They can be on cloud or on some premise, they can provide you some External API, of some kind: WebServer, Rest Call, FTP, Web Socket, MQTT, etc.
    - **External API:** to interoperate with any other application and service / servers.
    - **External Services / Web Pages:** to host into the user interface and Dashboards elements coming from third party applications.
    - **Tools:** which can be actual software or hardware tools, and also data analytics, algorithms, procedures.

Snap4City Innovation Matrix and Process

Part 6



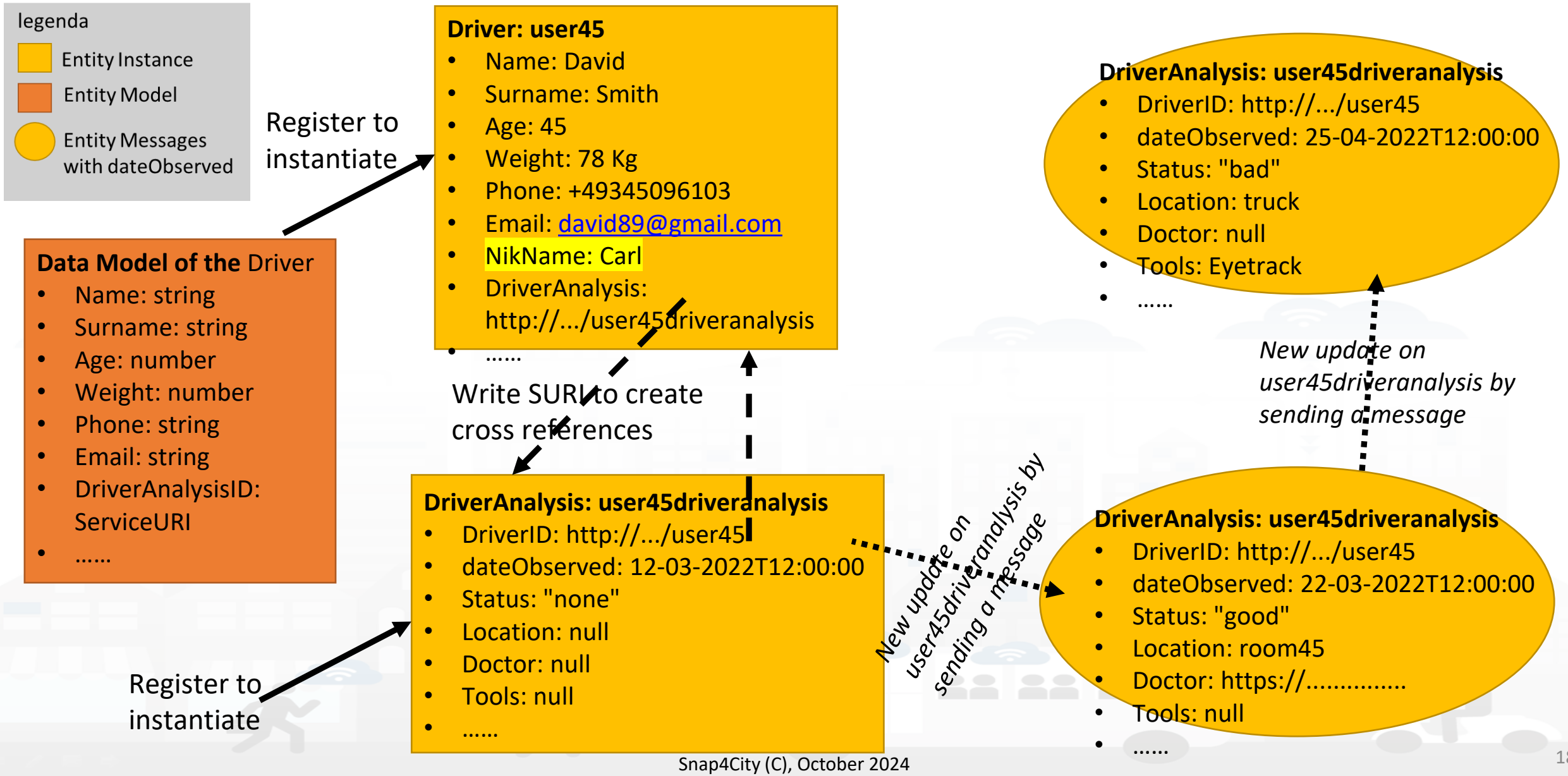


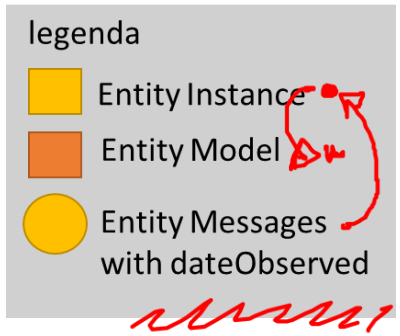
The Dictionary of Entities

Dictionary of Entities					
Term	DataModel or Module	Kind	Responsible	Status	Spec where
Driver Healthiness	DriverHealthiness	Entity Model	Dr. Rick Ross	To be done	To be defined
User profile A	DriverA	Entity Model			
Vehicle Event	VehicleEvent	Entity Model			
Remote Consolle	MyOperation	Application	J.T. Kirk	To be done	lost
		IoT App			
		Dashboards			

Columns in green are expected to be filled in the design phase

- **For example:** *Let us now to suppose that we have to develop a solution for monitoring Vehicles and Drivers. Each Vehicle has a profile description and can be driven by a number of Drivers over time.* ***Each Vehicle*** *can experience some maintenance and performs trips in the city area. A trip has an official start/end and over time is described by its velocity, acceleration, brakes, charging level, or thank level, etc.* ***Each Drive****r has a profile and can use a number of Vehicles to perform trips. During the trip also the Driver is monitored for its healthiness, attention, etc., and before, during and after the driving, periodically or sporadically may experience some Analysis to certify its capability to drive in that moment and for the next days. The Driver may experience some warning cases for healthiness, some tickets from policeman, some warning for high-speed velocity or generically bad driving, some problems from the vehicle's status, etc.*


legenda
Entity Instance
Entity Model
Entity Messages with dateObserved
Register to instantiate
Data Model of the Driver
Name: string
Surname: string
Age: number
Weight: number
Phone: string
Email: string
DriverAnalysisID: ServiceURI
……
Driver: user45
Name: David
Surname: Smith
Age: 45
Weight: 78 Kg
Phone: +49345096103
Email: david89@gmail.com
NikName: Carl
DriverAnalysis: http://.../user45driveranalysis
……
Write SURI to create cross references
DriverAnalysis: user45driveranalysis
DriverID: http://.../user45
dateObserved: 12-03-2022T12:00:00
Status: "none"
Location: null
Doctor: null
Tools: null
……
Register to instantiate
New update on user45driveranalysis by sending a message
DriverAnalysis: user45driveranalysis
DriverID: http://.../user45
dateObserved: 22-03-2022T12:00:00
Status: "good"
Location: room45
Doctor: https://.....
Tools: null
……
New update on user45driveranalysis by sending a message
DriverAnalysis: user45driveranalysis
DriverID: http://.../user45
dateObserved: 25-04-2022T12:00:00
Status: "bad"
Location: truck
Doctor: null
Tools: Eyetrack
……



Register to instantiate

Data Model of the Driver
- Name: string
- Surname: string
- Age: number
- Weight: number
- Phone: string
- Email: string
- DriverAnalysisID: ServiceURI
- ……

Driver: user45
- Name: David
- Surname: Smith
- Age: 45
- Weight: 78 Kg
- Phone: +49345096103
- Email: david89@gmail.com
- NikName: Carl
- DriverAnalysis: http://.../user45driveranalysis
- ……

Write SURI to create cross references

DriverAnalysis: user45driveranalysis
- DriverID: http://.../user45
- dateObserved: 12-03-2022T12:00:00
- Status: "none"
- Location: null
- Doctor: null
- Tools: null
- ……

Register to instantiate

New update on user45driveranalysis by sending a message

DriverAnalysis: user45driveranalysis
- DriverID: http://.../user45
- dateObserved: 25-04-2022T12:00:00
- Status: "bad"
- Location: truck
- Doctor: null
- Tools: Eyetrack
- ……

New update on user45driveranalysis by sending a message

DriverAnalysis: user45driveranalysis
- DriverID: http://.../user45
- dateObserved: 22-03-2022T12:00:00
- Status: "good"
- Location: room45
- Doctor: https://.....
- Tools: null
- ……

API, External Services

External API						
API name	API url and shape	Kind	parameter	Credentials approach	status	Description, Swagger link, Postman, …
	GIS…					
	CKAN…					

Columns in green are expected to be filled in the design phase

External Services				
URL Web pages	parameter	Description	Nature	Subnature

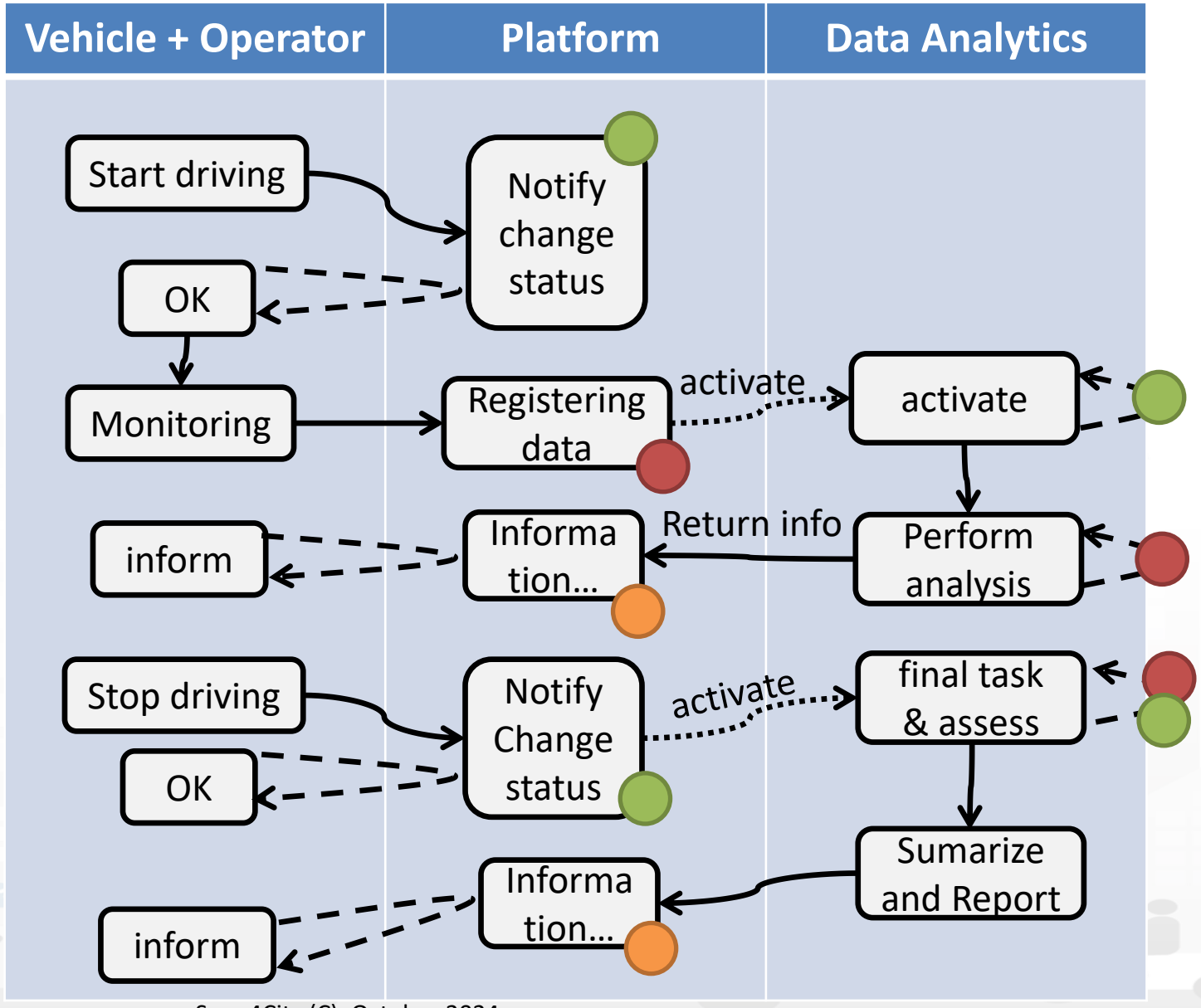
These info can be loaded on Snap4City platform to show them on dashboards easily

Analysis 2/2

- **Scenarios** describing the application/task, textual definition, with some standard table as UML. The scenarios have to refer to identified entities.
  - https://www.uml-diagrams.org/activity-diagrams-examples.html
- **Use Cases** describing the different cases into the single applications, by using UML formalization, there are specific Use Cases for each Scenario. Please focus on the most relevant, those that are adding value to your solutions. The others can be given for granted in a first phase.
- **Requirements** by using standard tables, using identified **Dictionary** of **Entities**, prioritizing them, setting mandatory/preferred/optional, functional and non-functional, first/second/third release, etc.
- **Sequence Diagrams:** for some of the critical aspects- For example for describing the user interaction, and/or the interaction among major entities, putting in evidence which is the Entity starting the dialogue with respect to the other **Entities** involved (e.g., a client requesting data to the server, a device sending data to the broker). UML sequence diagrams are a suitable formalization for the purpose.
  - https://en.wikipedia.org/wiki/Sequence_diagram

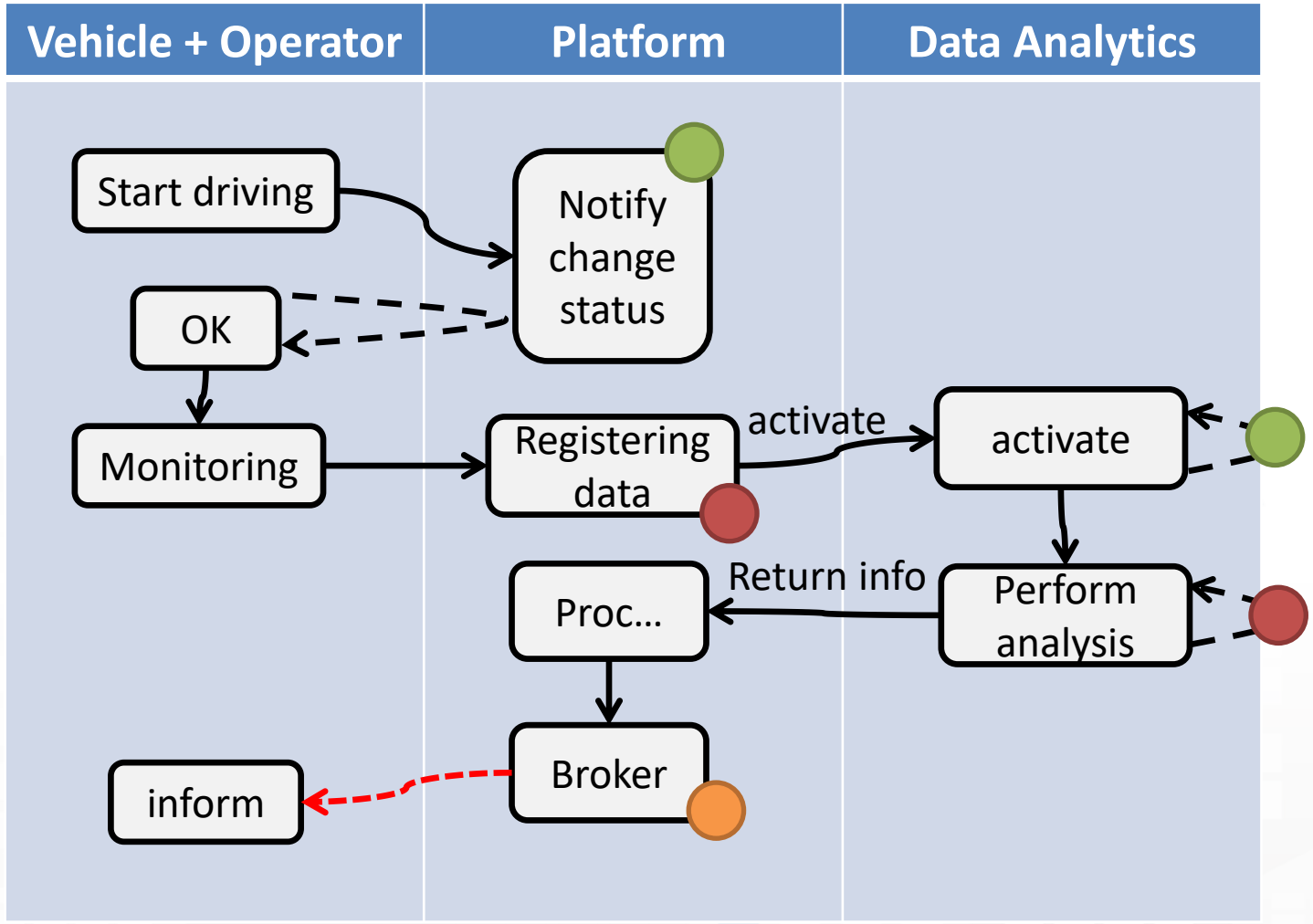
Example: Activity Diagram

- **Continuous Lines** can denote event driven, sync communications… for example by sending data on IoT Broker
- **Dashed lines** can denote Pull data collected. Via Async. Communication from Platform to Mobile Devices, via SCAPI
- **Dotted line** can be even driven internal mechanism, internal call of API or other event drv.
- **Coloured Dots** are the different devices data storage



A variant

- Every time a data is entered into the Storage an event occurs into the broker
- The server «Inform» can be subscribed from an IoT App to receive in push these changes **(red dashed line)**



A variant

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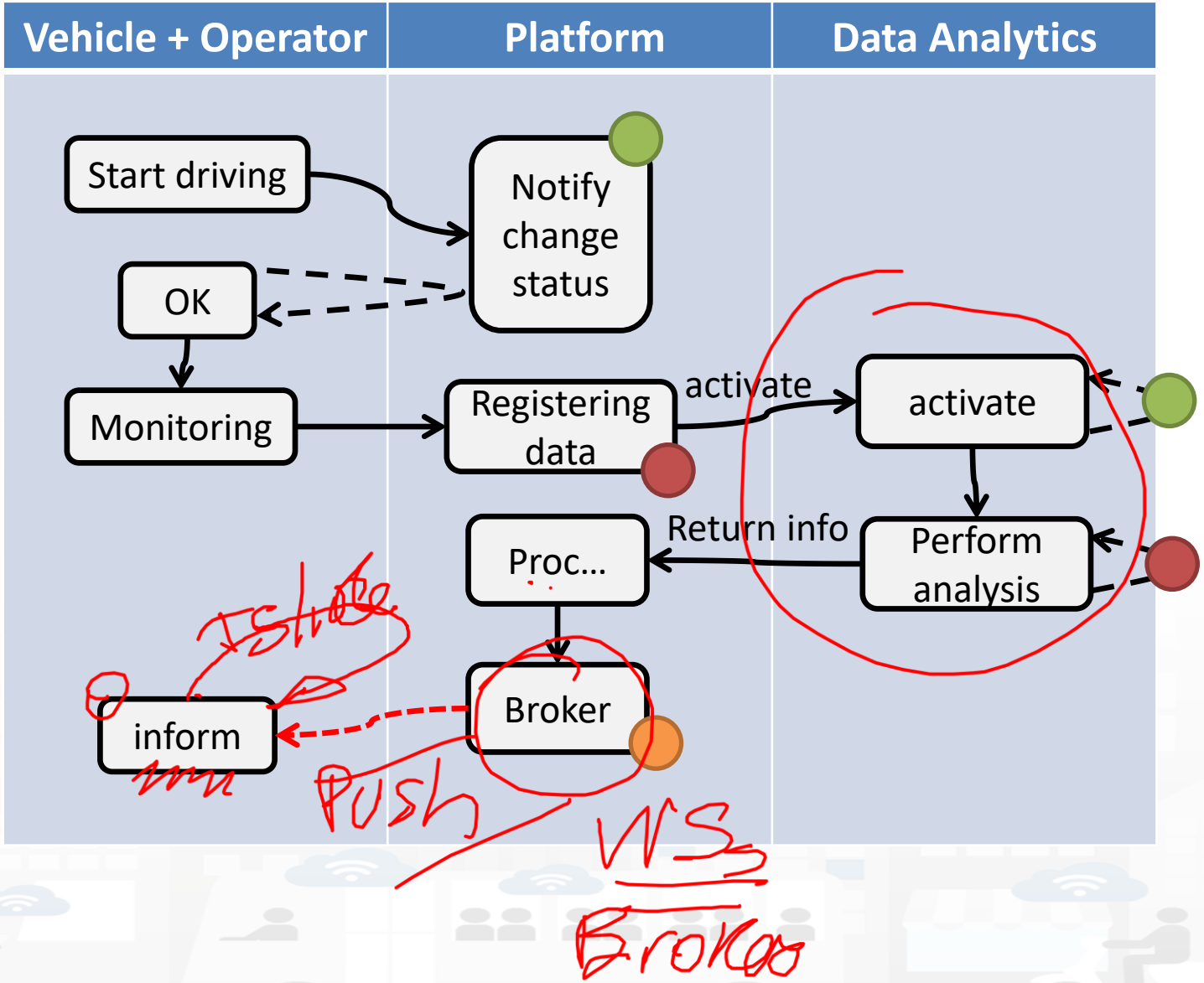


The above figure

- The driver on its Mobile App, he/she marks the start of the driving section, and the App notifies the change of status to the platform via some broker, once performed all the needed verifications (taking some minutes, may be).
- The effective change and authorization to start is made accessible by the platform to the mobile app which is requesting the status in pull (dashed line).
- Then the mobile app starts to monitor the drive status continuously, and send new data (e.g., the level of attention, the road taken, etc.) to the platform via some broker every minute.
- The arrival of new data may activate some data analytics to perform some analysis of the collected data (red dots) and producing results on the platform data. In the case in which the process detected critical conditions for the driver, the assessment procedure on platform may decide to send an event/message (dashed red, in push from platform to clients) to the operator and driver via a Broker to warning the driving of the lack of attention or for some wrong path.
- The event in push from platform to client could be a viable approach on some platforms and may have some limitation on Mobile App in which the interaction paradigm can be changed in a periodic REST call from the Mobile to the Platform.

Fun Requirements

Requirements						
ID	Main Entity / Area	Description	Relevance / Priority	Main Tool-Module / Entity involved	Status	Source Code
D1	Operator	The Operator has to be authorized to register Drivers	mandatory	OperatorTool	Not developed	JavaScript by xxxx on GitLab ….
D2	Driver	The Drive can verify its registration by putting Password to access to its data on the solution	optional	Web and/or Mobile App accessible for the Drivers	accessible as open source	Yes In Java with AGPL licence
	OperatorTool	Has to provide the list of pending assessment to be done				

Columns in green are expected to be filled in the design phase

Non Functional Requirements

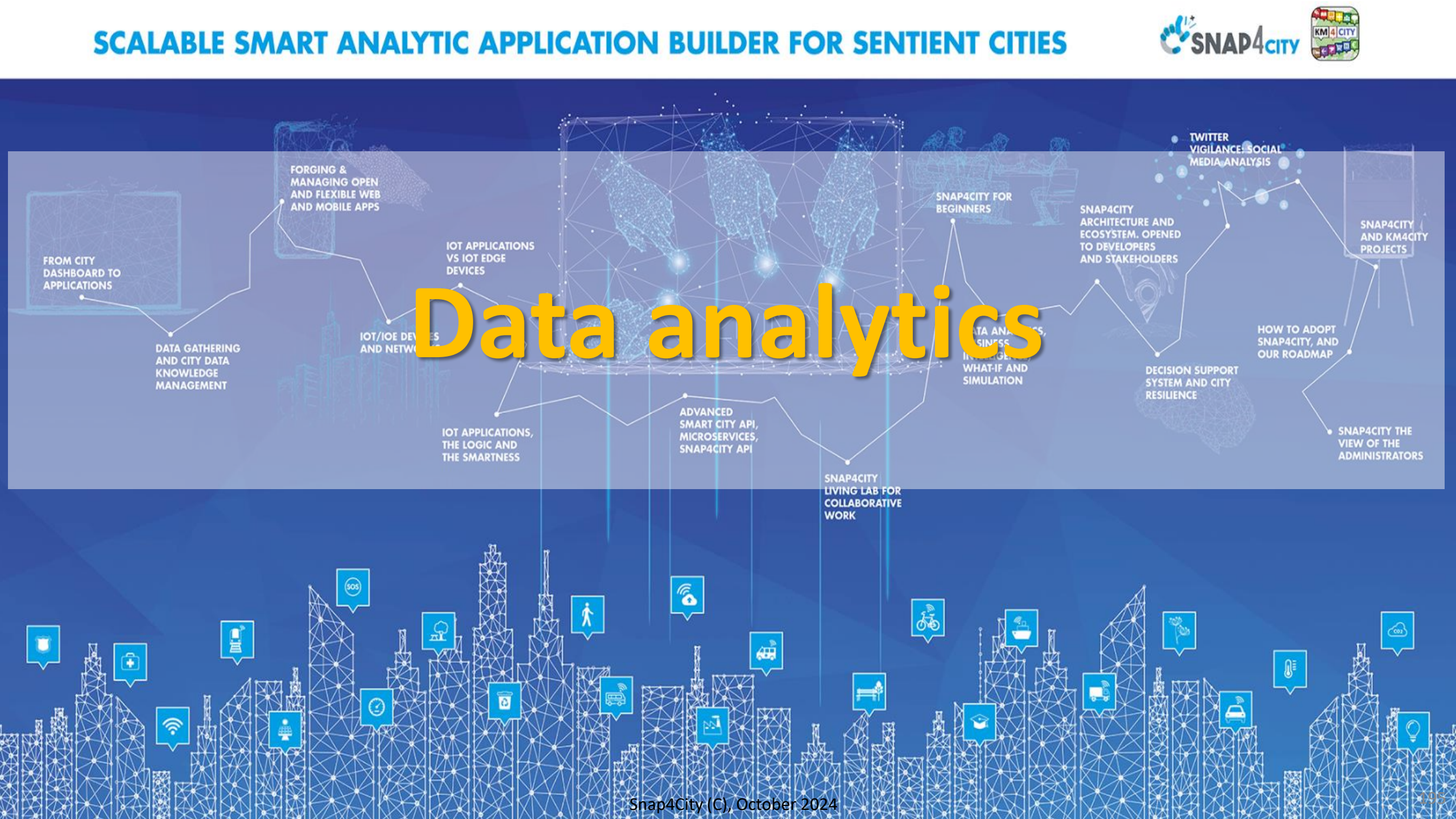
Somehow related each other

- Protection, privacy, PENTest, GDPR compliance, …
- Scalability, performance, efficiency, cloud/edge/container compliance
- Resilience, robustness
- Modularity, flexibility, reusability, maintainability, ..
- Portability, Openness, opensource
- Interoperability, standards compliance
- Responsive, usability, ..
- Etc.

All largely covered by Snap4City platform

Be carefull

- **Despite** the Snap4City platform provides a full range of Non-Functional Requirements
  - You can with your analysis and design produce poor solutions
- **For example, it is not a good approach to:**
  - Collect user profiles and putting them public
  - Collect data every 10 second of phenomena which change only once a day
  - Couple your web/mobile applications with server-side processes by using synchronous communication in a context which is not synchronous and neither real time



Data analytics

Available AI Solutions on Snap4City

https://www.snap4city.org/997

More than 80 Available Solutions & 300 AI applic.

- **Mobility and Transport**
- **Environment, Weather, Waste, Water**
- **City Users Behaviour and Social analysis**
- **Energy and Control**
- **Tourism and People**
- **Security and Safety**
- **High Level Decision Support Solutions**
  - **Asset management**
  - **Resilience and Risks Analysis**
- **Low level Techniques**

https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

https://www.snap4city.org/download/video/course/p4/

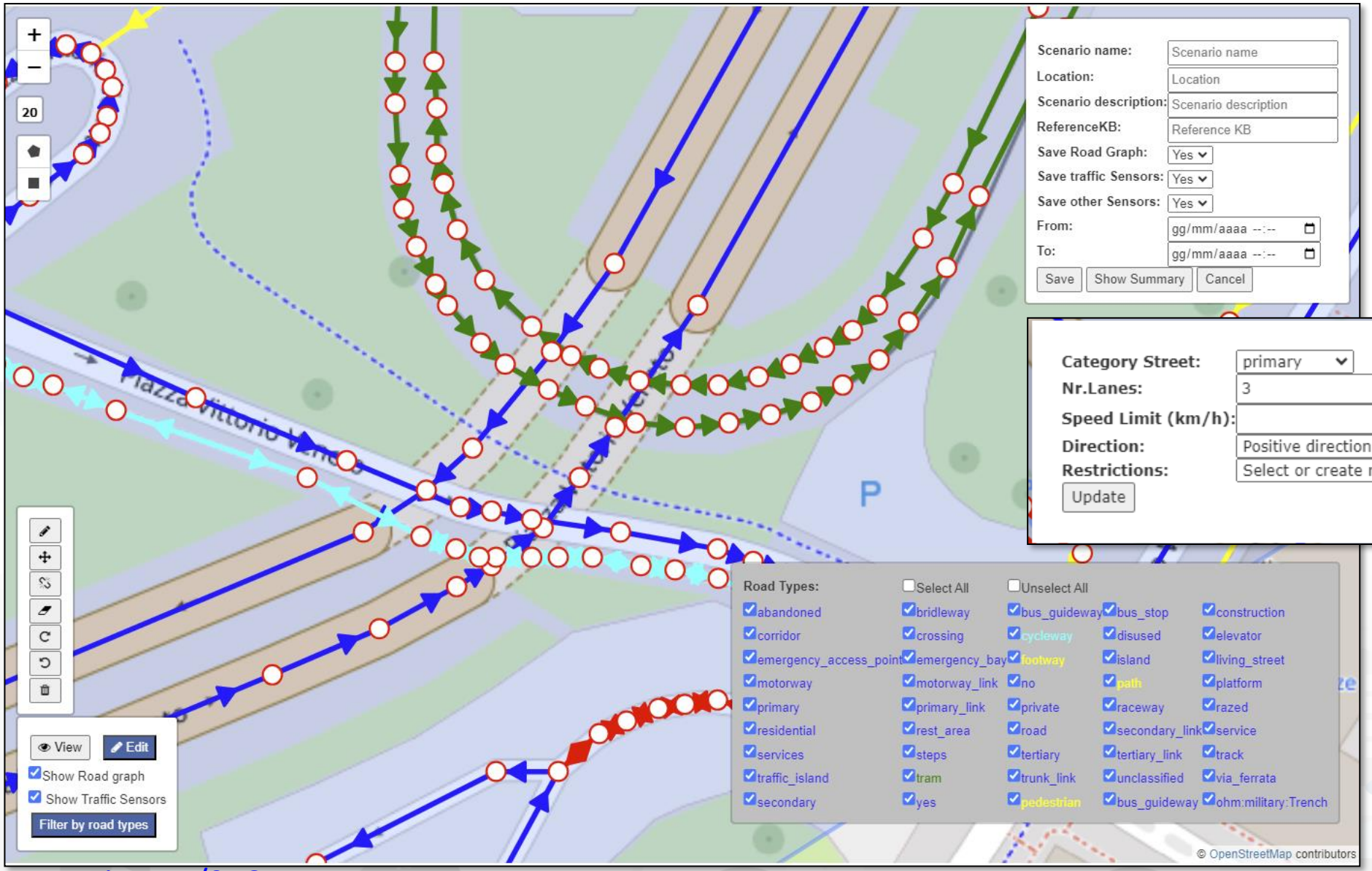
Scenario Editor

Select map

Zoom

New Scenario

Editing
Drag & drop
Split & Join
Delete
Do and Undo



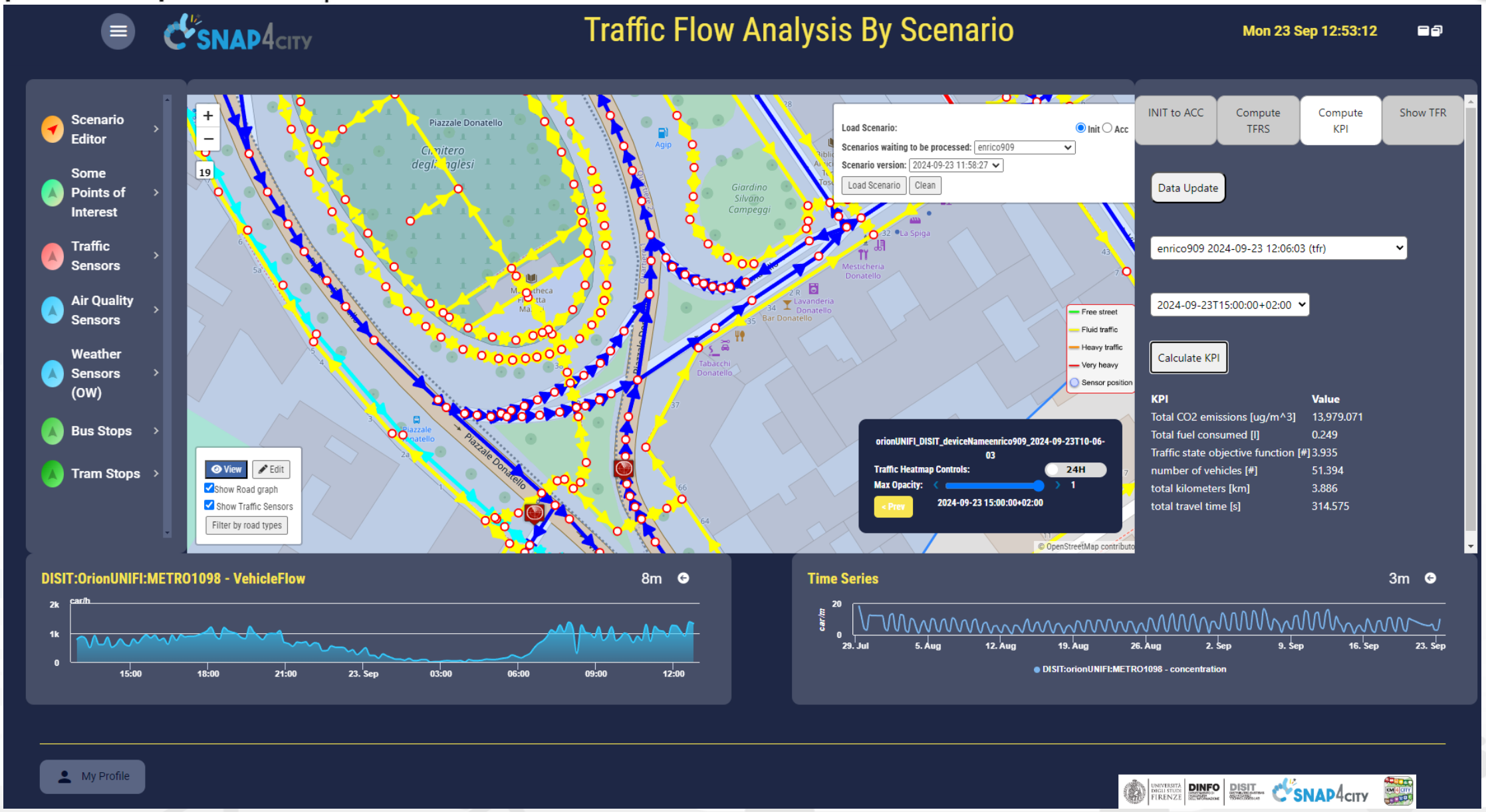
Edit Road Segment

- identifier
- composition
- elemLocation
- elementClass
- elementType
- length
- operatingStatus
- speedLimit
- trafficDir
- width
- highwayType
- route

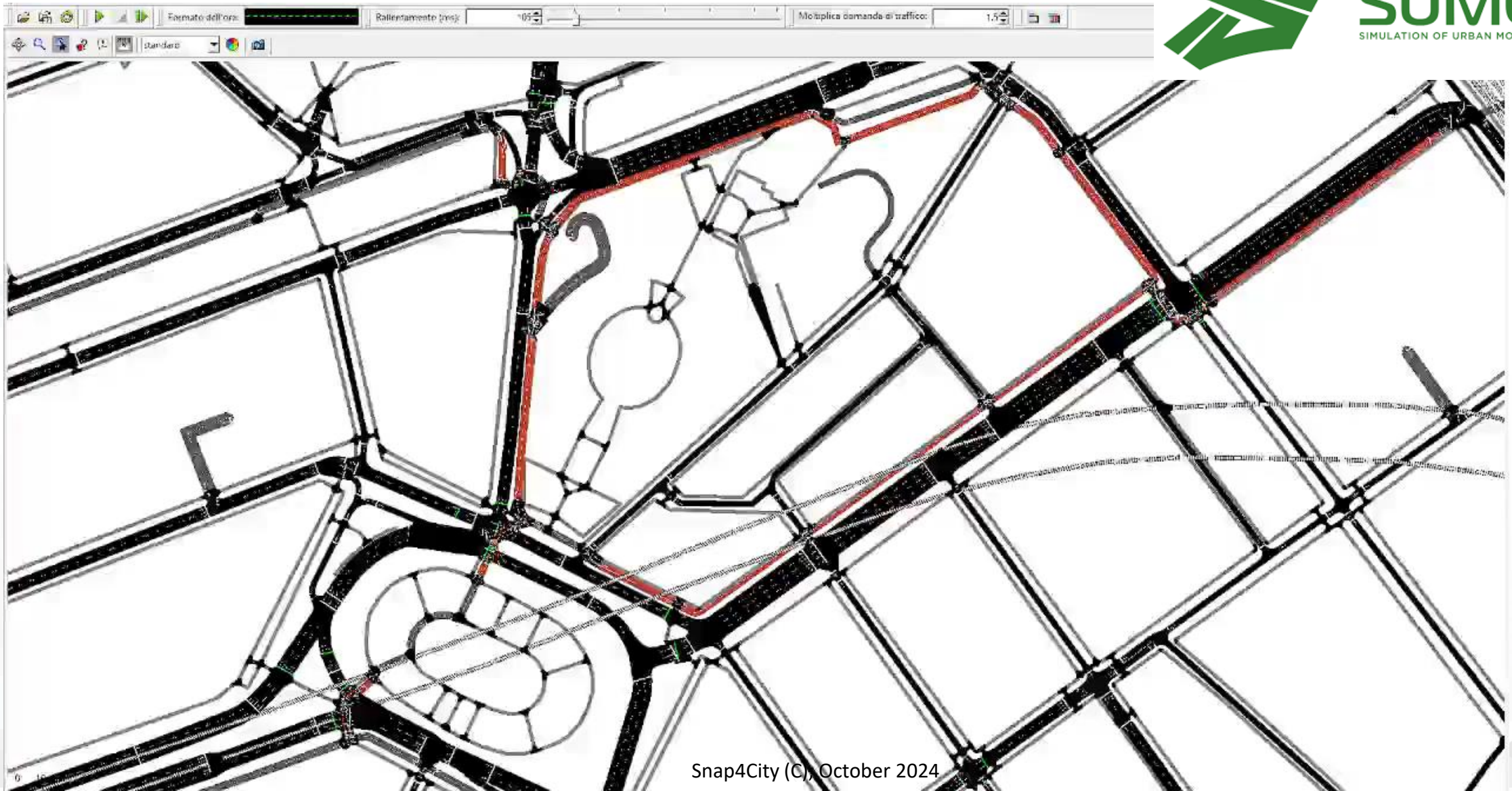
Properties of Road Elements

https://www.snap4city.org/976

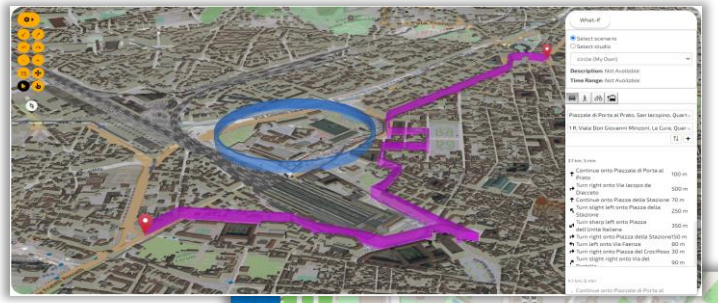
What-if on TFR

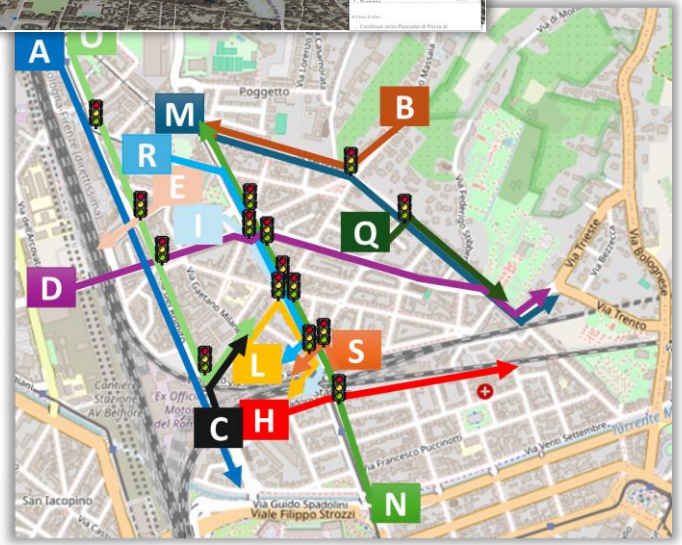


Micro Simulation



Mobility

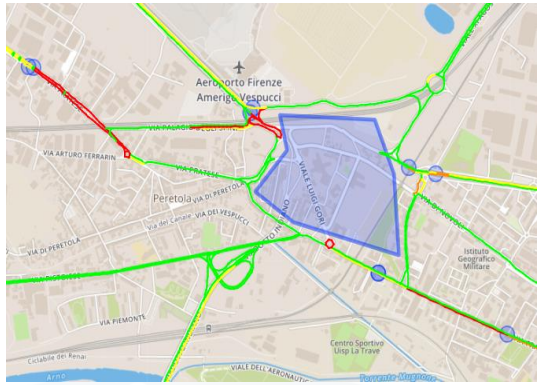


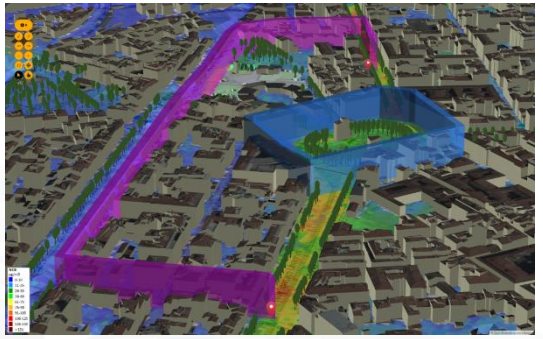


- **Goals:**
  - Decongestion, Decarbonization, costs reductions
  - Improve Accessibility to services
  - Improve Security/Safety of city users
- **Operation and Plan**:
  - Traffic monitoring, prediction, reconstruction, identification of critical conditions (early warning), fleet management, dynamic routing, multimodal routing, city user behaviour analysis
- **Optimization and what-if analysis traffic light, infrastructure**
  - **Reduction**: travel time, waiting time, stops, CO2 emissions, consume fuel, travel time for tramways
- **Public Transport**: analysis of Mobility Demand vs Offer of Transportation
- **Parking Management:** monitoring, prediction, any payments, on/off-road
- **Sharing / Pooling Management**: eShare and mobile app, bikesharing, smart bike, fleet management
- **KPI:** SUMI/SUMP, travel time, emissions, traffic status, accessibility, ..
- **Mobile App**: final users and operators
  - Info Mobility, traffic reconstruction, charging, participation,
  - Parking, payments, overparking, fine reporting, ..
- **Participatory**: problem reporting, ticketing, etc.
- **Data Integration of any kind: env, weather. Tickets, presences, POI, sat, etc.**

Mobility and Transport Domain (2024/8)

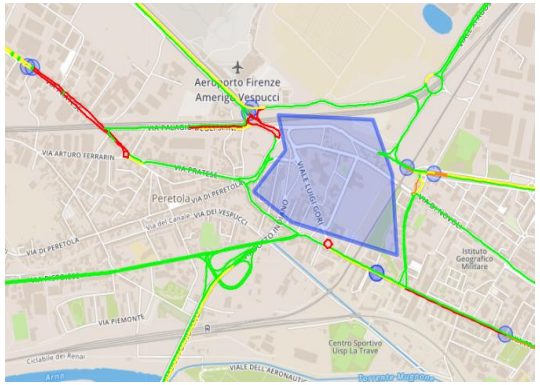
- Goals:
  - Decongestion
  - Decarbonization
  - Accessibility to services
  - Security/Safety of city users
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring traffic, parking, people flow, services, boats, ports, beaches, etc.
  - Early detection/warning of critical conditions: traffic, congestion, security/safety
  - Managing Smart Parking, transportation services, fines, etc.
  - Managing fleets: personal, sharing, waste collection, maintenance, etc.
  - Managing E-sharing, pooling services, MaaS, etc.
  - Managing entrances in city areas: restricted areas, touristic busses, etc.
  - Production of suggestions, recommendations, nudging
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction of traffic congestion, via optimization: traffic light plans, viability, routing
  - Reduction of Pollutant Emissions, via optimization: traffic light plans, viability
  - Optimization of transportation offers wrt multimodal mobility demand
- Algorithms and computational solutions, see next slide

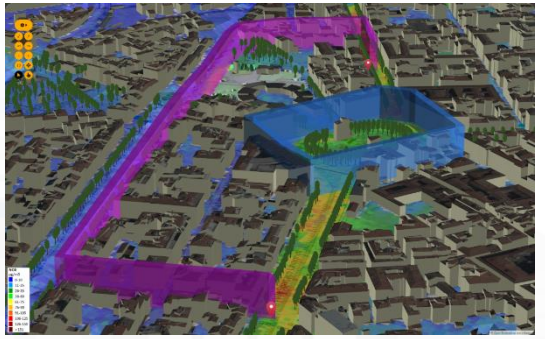




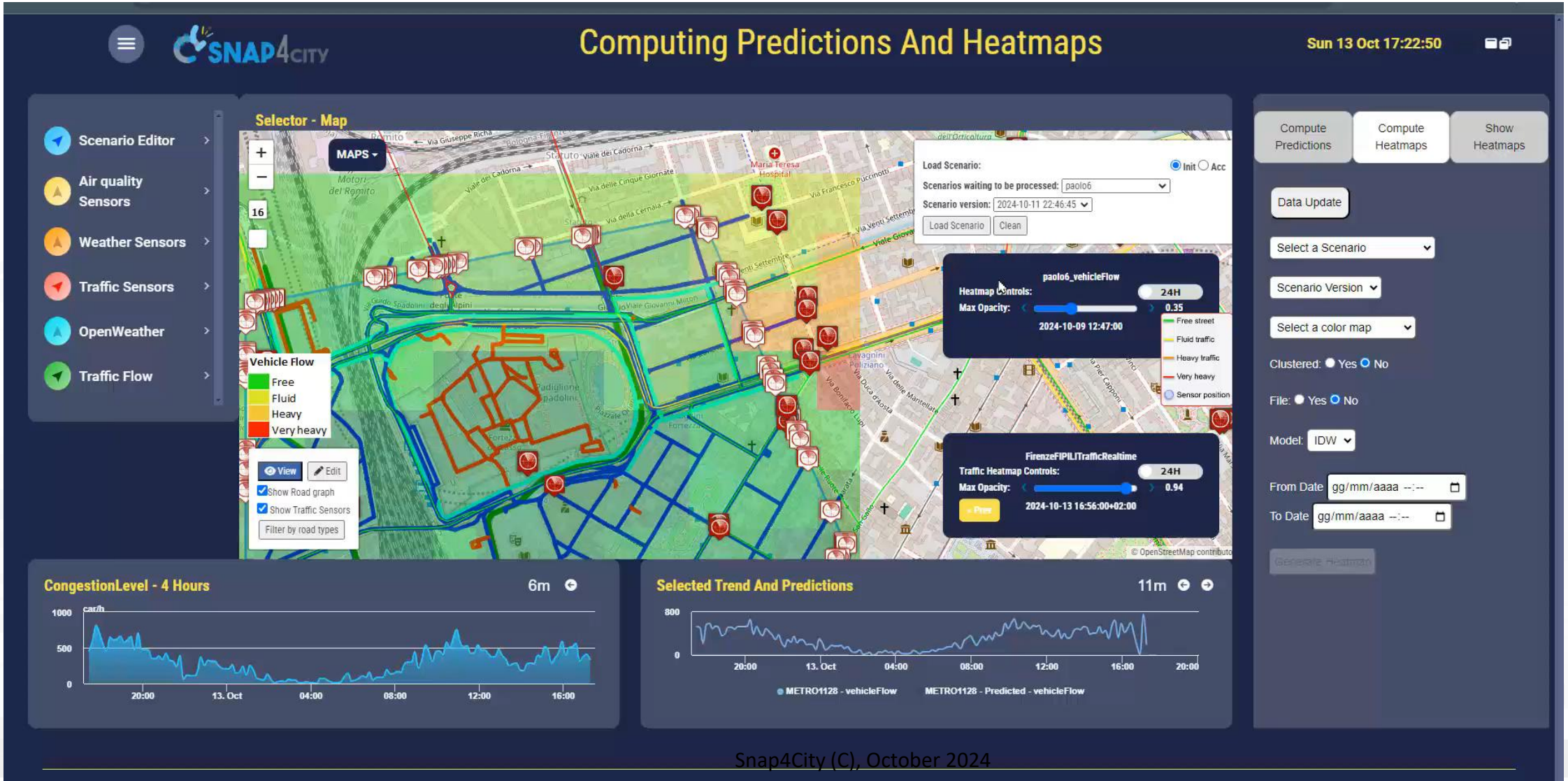
Tools for Mobility and Transport (2024/8)

- Optimisation of viability of an area for reducing congestion, waiting time, stops
- Optimisation of Traffic Light Plans, synchronization, in an area for reducing congestion, waiting time, stops
- Predictions for: traffic flow, smart parking, smart bike sharing, people flows, etc. (ML, DL)
- What if analysis: routing, traffic flow, demand vs offer, pollutant, etc. (Simulation + ML)
- Traffic flow reconstruction from sensors and other sources (simulation + ML)
- Public Transportation: Ingestion and modelling of GTFS, Transmodel, NeTEx, etc. (DP)
  - Analysis of the demand mobility vs offer transport of according to public transportation and multiple data sources (Simulation)
  - Assessing quality of public transportation (analysis)
- Accidents heatmaps, anomaly detection (analysis, ML)
- Road light controlled by traffic conditions
- Tracking fleets, people, via devices: OBU, OBD2, mobile apps, etc. (DP)
- Routing and multimodal routing (multistop travel planning), constrained routing, dynamic routing (DA)
- Computing Origin Destination Matrices from different kind of data (analysis, DP, DP)
- Computing typical trajectories on the basis of tracks (analysis, ML)
- Fleet management, monitoring, booking, allocation, maintenance
- Computing Messages for Connected drive (DP)
- Slow and Fast Mobility 15 Minute City Indexes (analysis, DP, …ML)
- Computing and comparing traffic flow on devices and at the city border (analysis)
- Typical time trends for traffic flow and IoT Time series. (analysis, ML)
- Impact of COVID-19 on mobility and transport
- Computing SUMI, PUMS, etc. (mainly DP)
- Definition of Scenarios: traffic, road graph, conditions, etc.
- Etc.





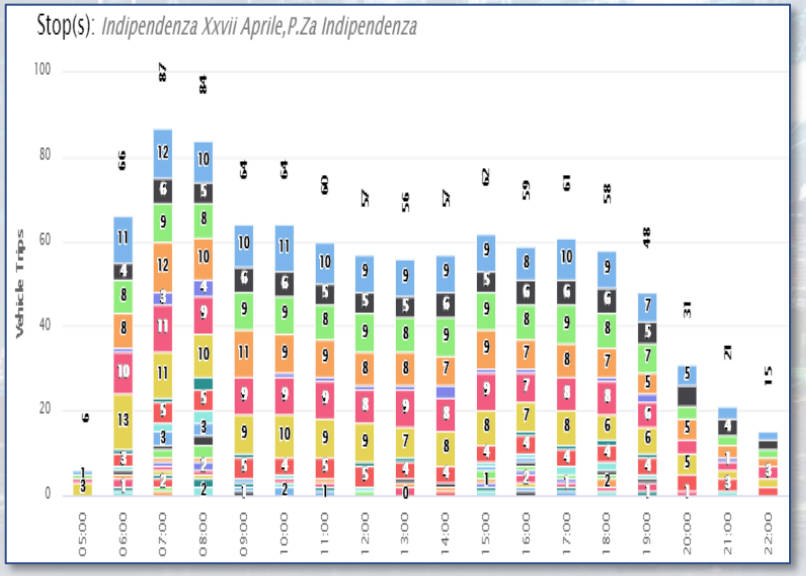
Predictions and Heatmaps in Real Time

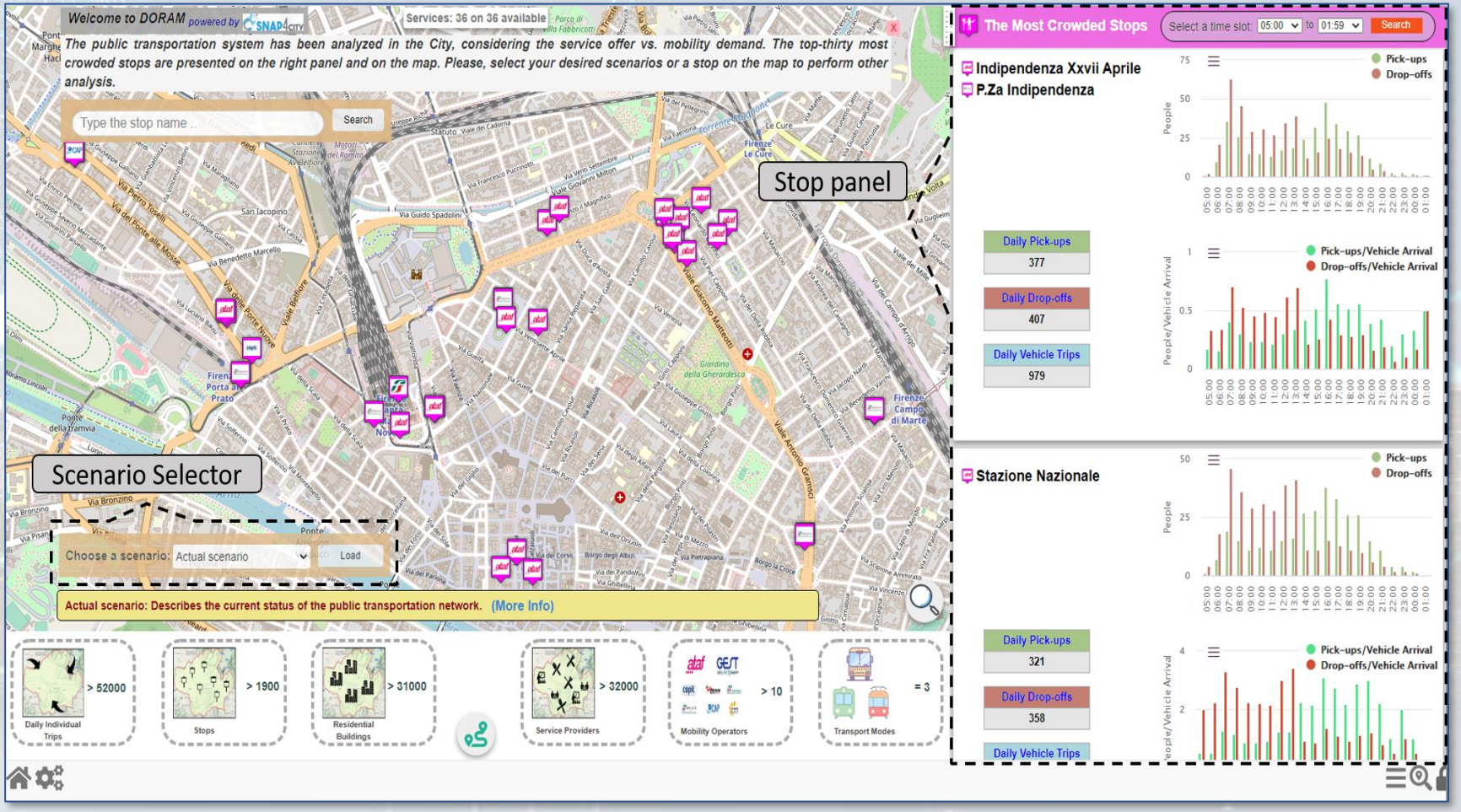


What-if Analysis on Pub Transport

- Simulation / analysis of Demand and Offer of transportation
- Definition of scenarious impact on
  - Traffic, Pollutant, parking, public transport, private flows, etc.
  - KPI analysis

Public Services

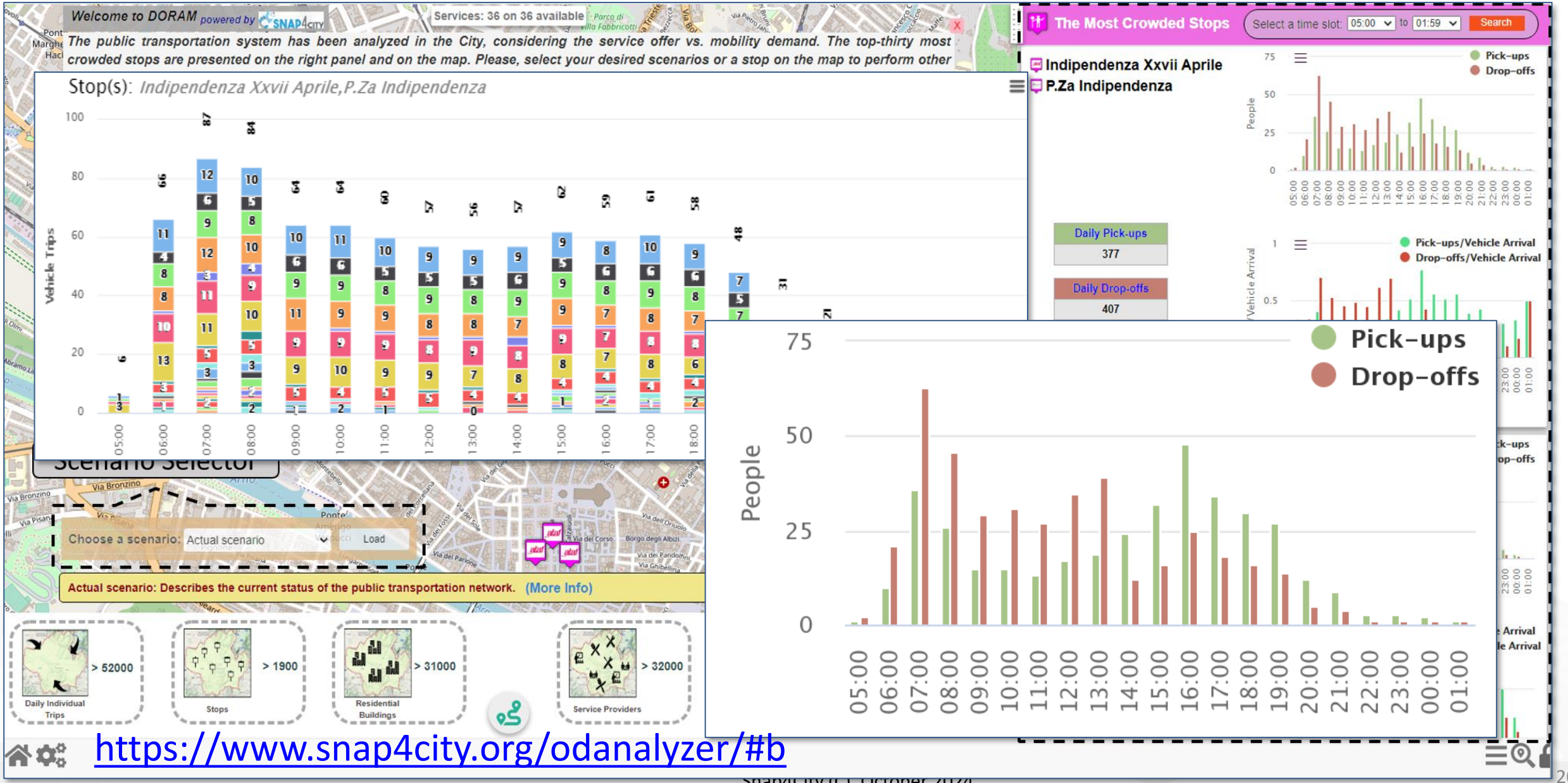




UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

DORAM

SNAP4CITY | KM 4 CITY



https://www.snap4city.org/odanalyzer/#b

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SNAP4CITY | KM4CITY

Traffic Light Plan Optimization

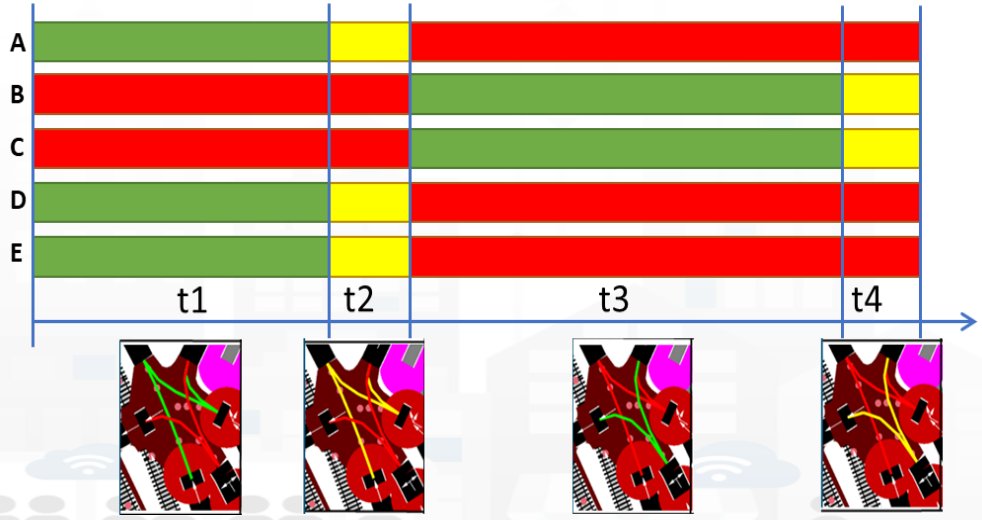
MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

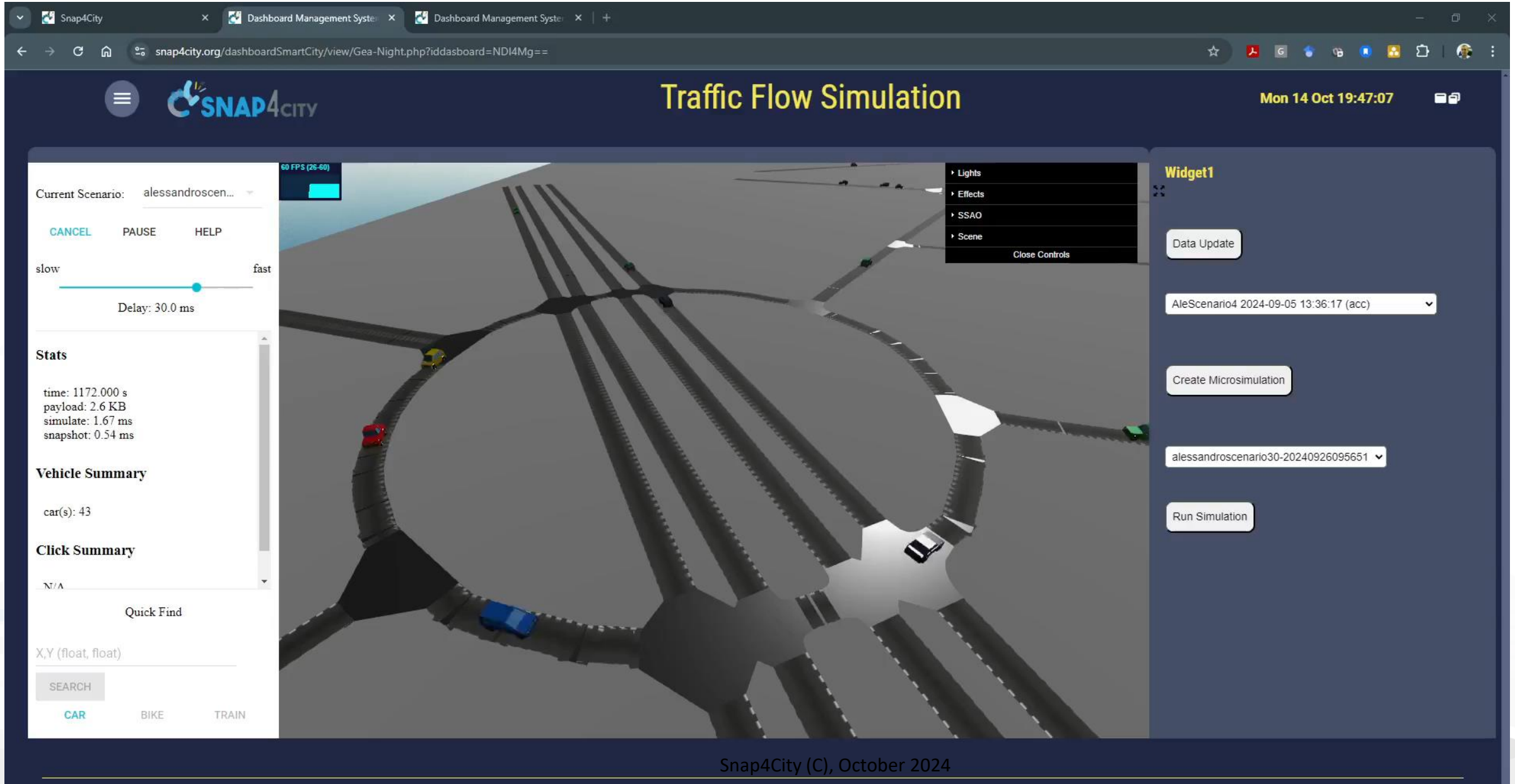
11 SUSTAINABLE CITIES AND COMMUNITIES

https://www.snap4city.org/1015

Traffic Light Plan Optimisation, Digital Twin

- **Match Multiple Objectives and Synchronization:**
  - public and private traffic, tramway priority
  - Micro and Macro Scales
  - **AI: Genetic Algorithms, Reinforced Learning**
    - Fixed and Actuated Cycles
    - Adjusted on Demand
- **Validation/integ.** with ***SUMO*** simulation
  - Travel Time, waiting time, waiting count, specific travel time on directions, CO2 emissions, etc.
- **Reductions from 5% to 15%**




Snap4City
Dashboard Management Syste
Dashboard Management Syste
snap4city.org/dashboardSmartCity/view/Gea-Night.php?iddasboard=NDI4Mg==
SNAP4CITY
Traffic Flow Simulation
Mon 14 Oct 19:47:07
Current Scenario:
alessandroscen...
CANCEL
PAUSE
HELP
slow
fast
Delay: 30.0 ms
Stats
time: 1172.000 s
payload: 2.6 KB
simulate: 1.67 ms
snapshot: 0.54 ms
Vehicle Summary
car(s): 43
Click Summary
N/A
Quick Find
X,Y (float, float)
SEARCH
CAR
BIKE
TRAIN
60 FPS (26-60)
Lights
Effects
SSAO
Scene
Close Controls
Widget1
Data Update
AleScenario4 2024-09-05 13:36:17 (acc)
Create Microsimulation
alessandroscenario30-20240926095651
Run Simulation

Mean Travel Time

	Traffic Load	MTTall	MTT dir_N	MTT dir_M	MTT dir_A	MTT TW Careggi	MTT TW Costanza
4TW-NTNS-MWD-P	1.5	3542.50	198.90	**242.14**	197.64	**436.00**	**427.00**
4TW-NTNS-MWD-A	1.5	**3242.71**	**178.33**	**243.28**	**195.79**	**436.00**	**427.00**
4TW-NTNS-MWD-P-A	1.5	**3242.71**	**178.33**	**243.28**	**195.79**	**436.00**	**427.00**
2TW-NTNS-MWD-P	1.5	4538.02	207.40	456.14	615.00	**436.00**	**427.00**
2TW-NTNS-MWD-A	1.5	3940.07	**179.30**	428.67	481.53	**436.00**	429.75
2TW-NTNS-MWD-P-A	1.5	4380.63	182.05	456.59	654.21	**436.00**	**427.00**
SUMO Actuated	1.5	3409.13	280.09	515.34	200.66	497.54	499.81
Webster	1.5	6474.95	465.45	441.93	210.50	1379.25	493.87
WebsterAdjusted	1.5	4035.08	195.82	441.09	205.66	463.87	447.06

4TWD-NTNS-MWD-P-A: optimization by prioritizing traffic **directions,** the normalized number of vehicles stops, $NTNS$, the mean waiting delay MWD, for all traffic lights, and post synchronization, with Penalty and Adjust dynamically performed

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

SNAP4CITY | KM 4 CITY

Traffic Infrastructure Optimization

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

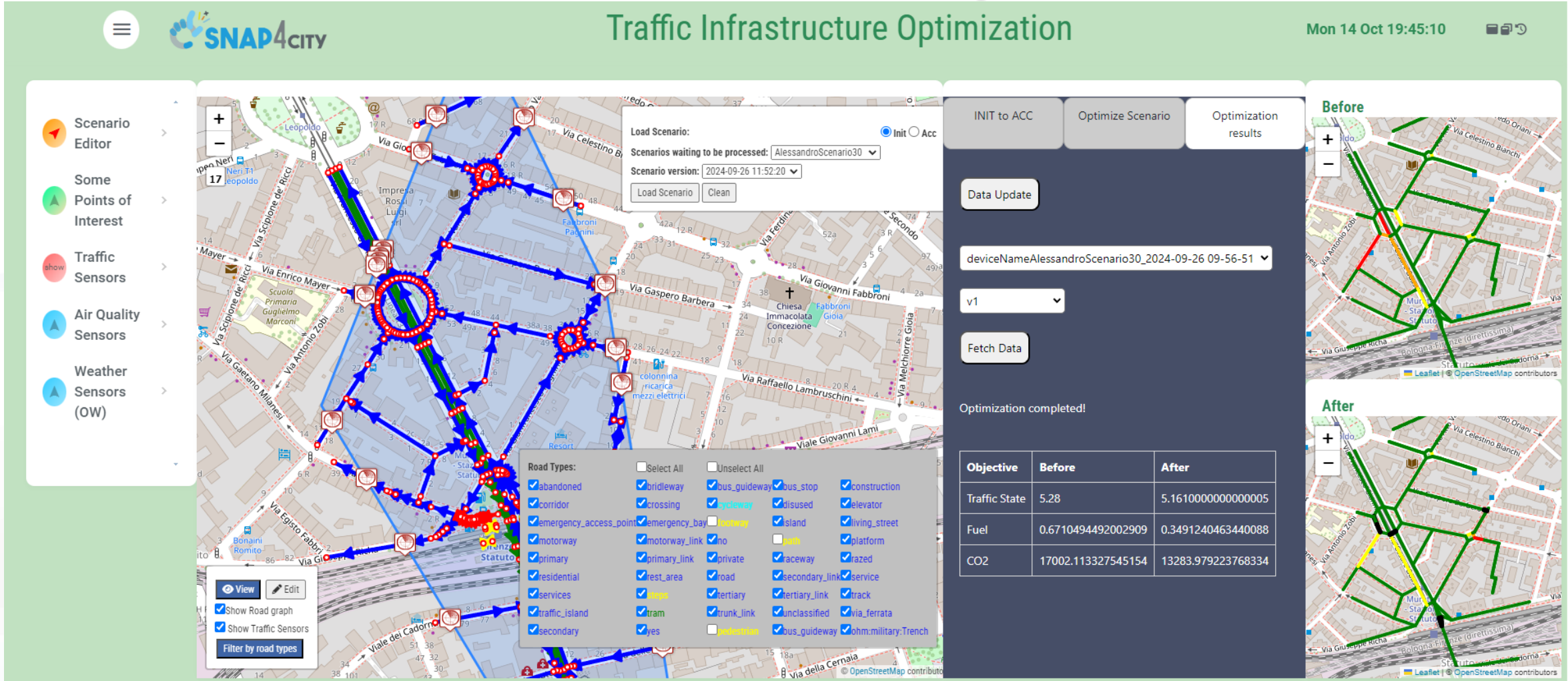
FROM CITY DASHBOARD TO APPLICATIONS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

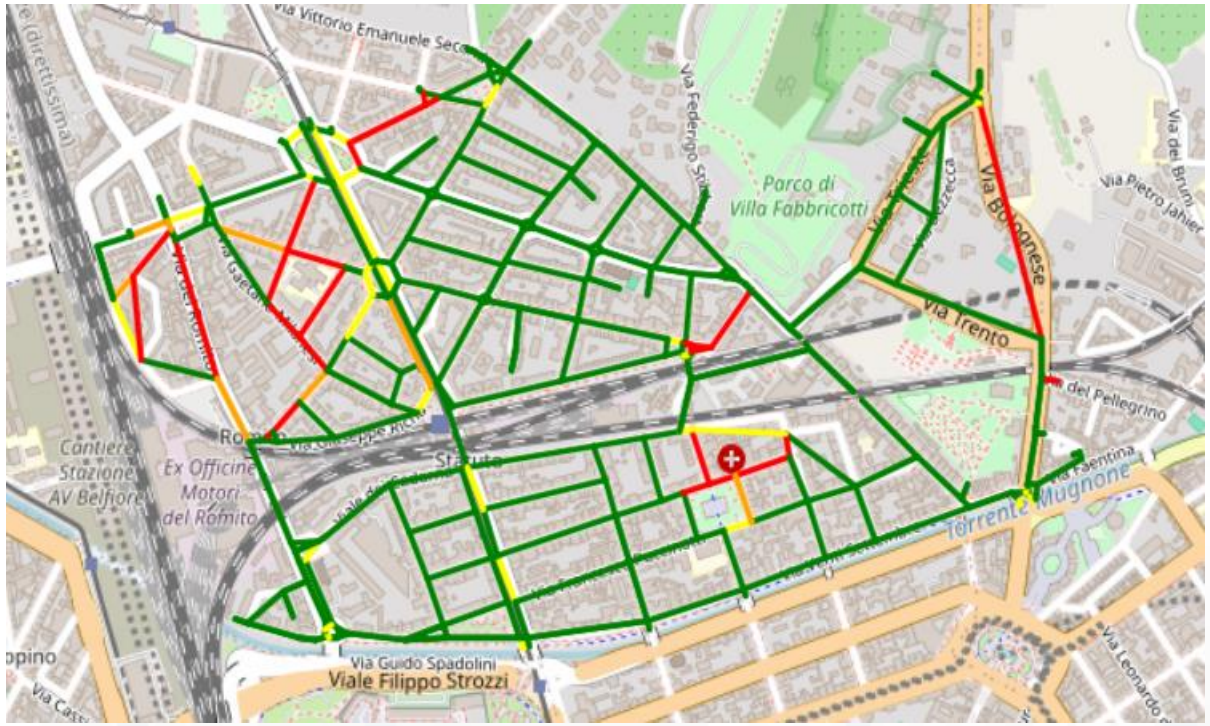
11 SUSTAINABLE CITIES AND COMMUNITIES

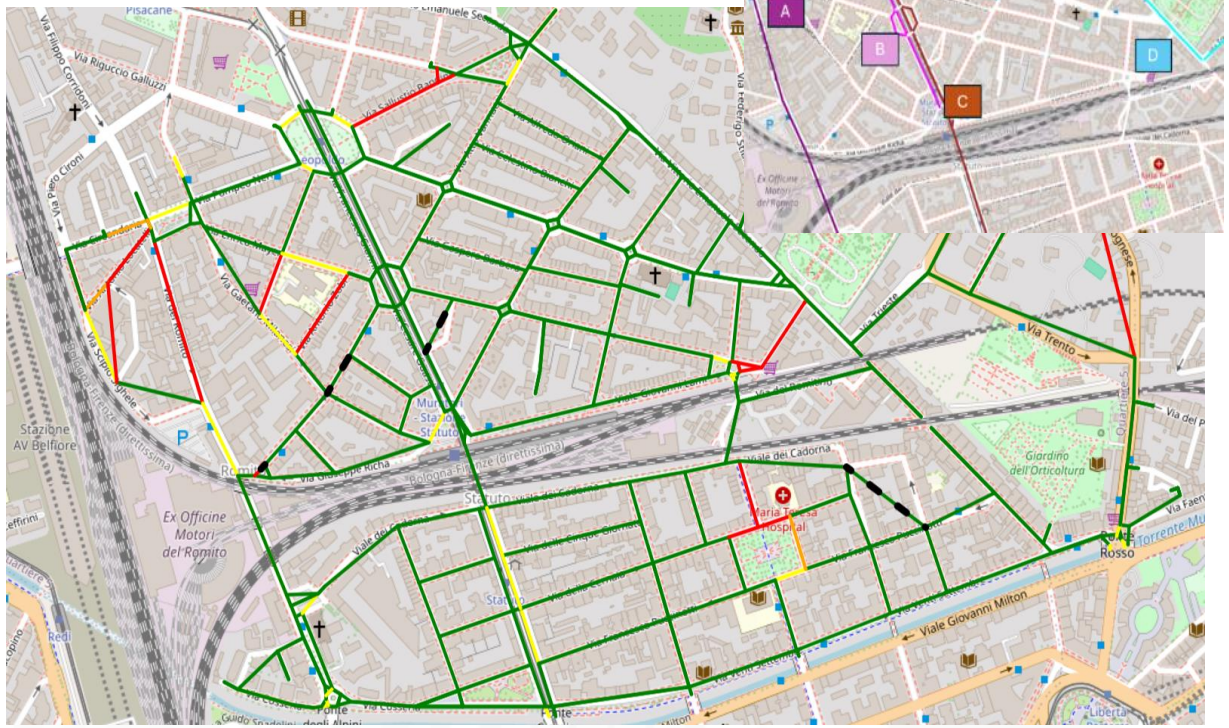
https://www.snap4city.org/1014

Traffic Infrastructure Optimization



Optimization Results



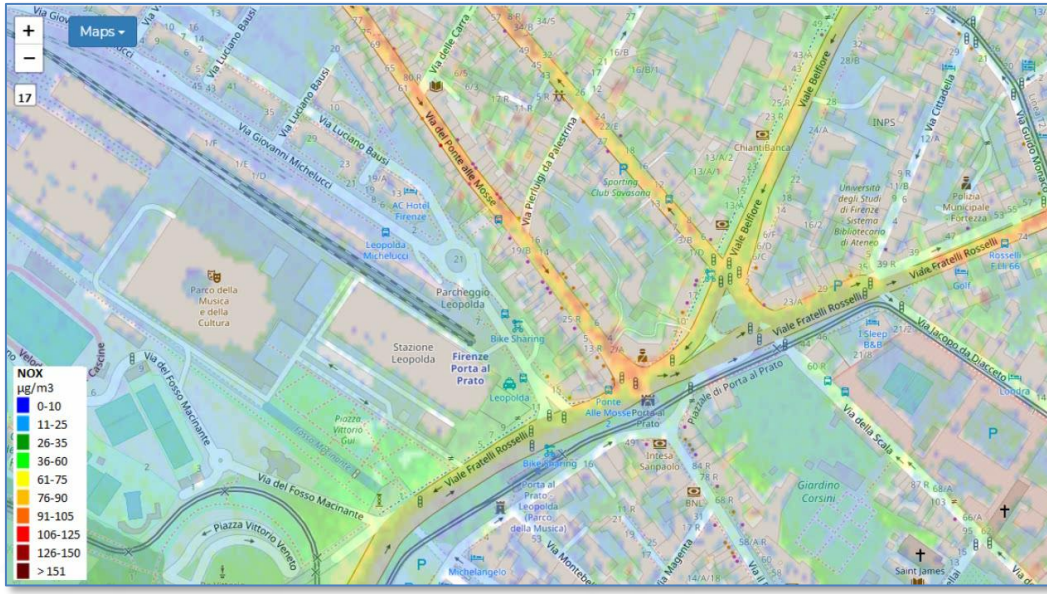


Case max 4 changes	*KPI estimation on the best solution*		
Optimization Target	***Traffic State***	***Fuel***	***CO2***
Optim 4 Traffic State	**91.341** -21%	17.964	128536
Optim 5 Fuel	91.514	**16.633** -35%	128227
Optim 6 CO2	92.859	19.192	**127876** -23%
Original	115.475	25.680	165822

Travel Time [s]	*Path A*	*Path B*	*Path C*	*Path D*	*Total Time*
Original Scenario	183.2	59.6	80.9	132.5	456.4
Optim 4 Traffic State	93.2	60.0	63.7	**96.0**	313.1
Optim 5 Fuel	89.6	**51.2**	59.7	96.4	**296.9**
Optim 6 CO2	**89.5**	53.2	**58.4**	100.1	301.3
	-51%	-14%	-28%	-28%	

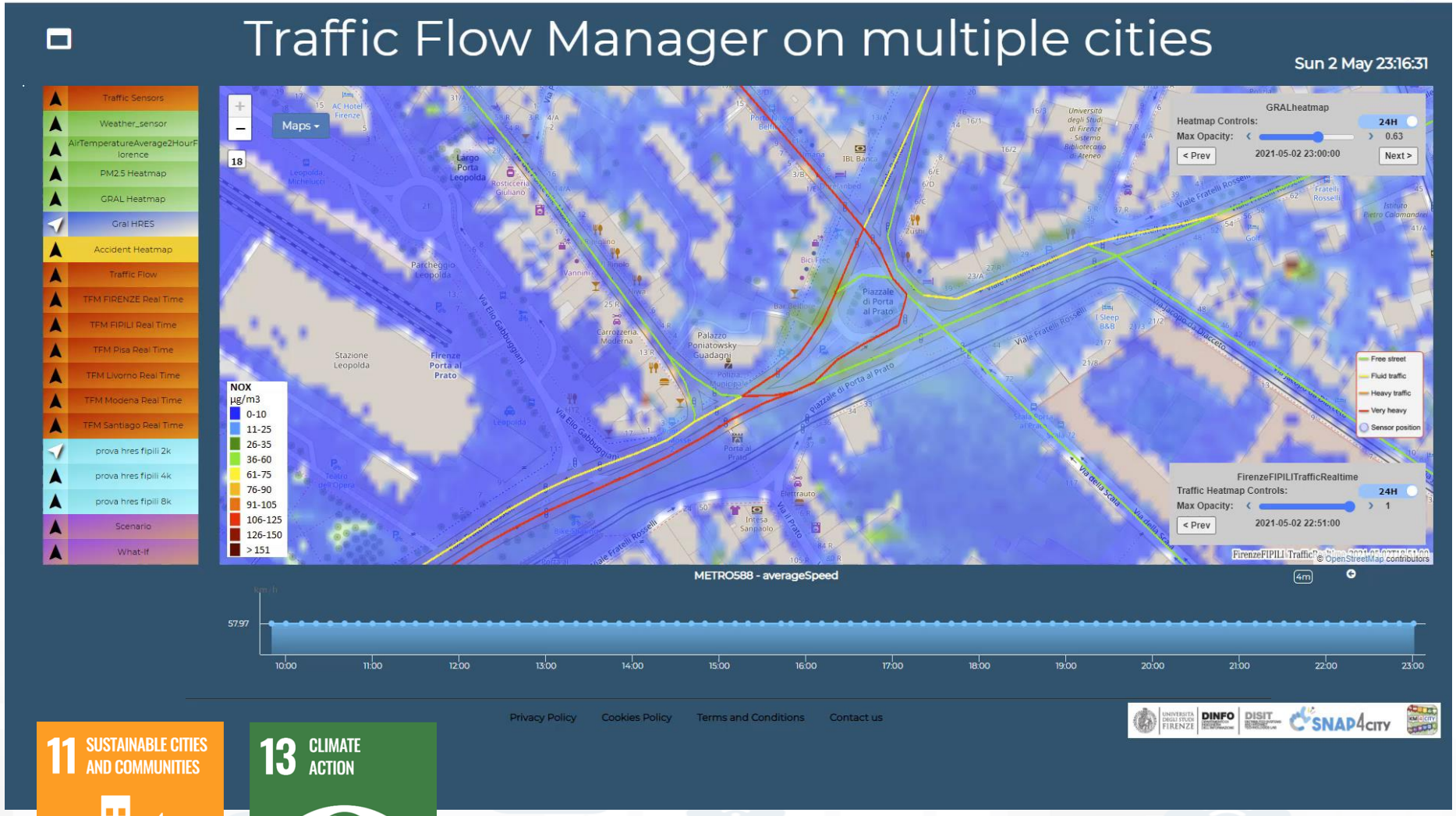
Environment and Waste

- **Goals:**
  - Reduction of emissions and EC taxations
  - Cost reduction for waste collection,
  - reduction of waste collection impact on mobility
- **Environment Management producing prescriptions:**
  - Monitoring and long and short-term predictions, warning for:
    - GHG, emissions, pollutants, aerosol, chemical plants analysis
    - land slide, coastal erosion (blue economy)
  - Traffic Flow impact emissions, predictions
  - What-if analysis, optimisation tools
- **Waste Management and Optimisation:**
  - costs reduction, optimal routing production, pay as you throw,
  - avoiding out of bins, predictions of waste production on bins, alarms
- **KPI:** SDG, 15MinCityIndex, QOS, costs, Km, colleting time, EC KPI, emissions
- **Mobile App**: final users services/informing and operators
  - Info Waste for operators, participation, optimal routing, RAEE Collection, ..
- **Participatory**: problem reporting, ticketing, etc.
- **Integration of any kind: env/weather, mobility, ticketing, presences, POI, ..**



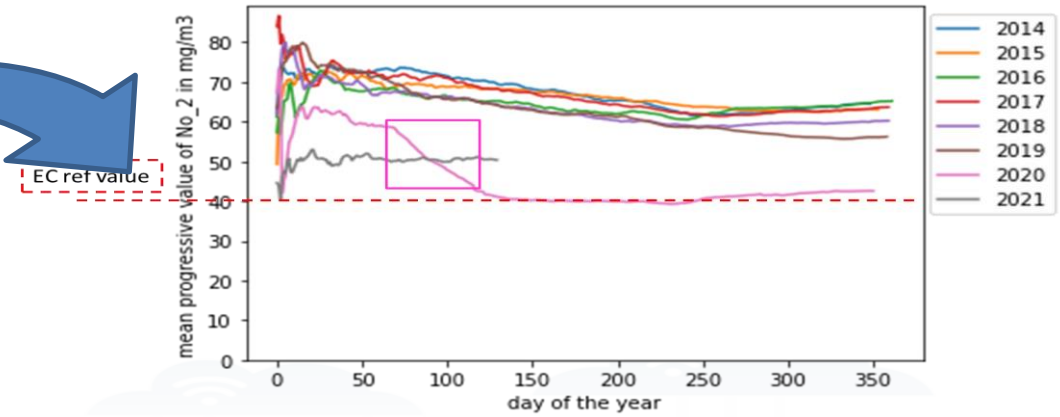
Environment

- **Prediction**
  - **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
  - **NO2 progressive average** (Long term)
- **Project:**
  - **Trafair** CEF EC
  - Mixed solutions of Fluidinamics modeling and AI

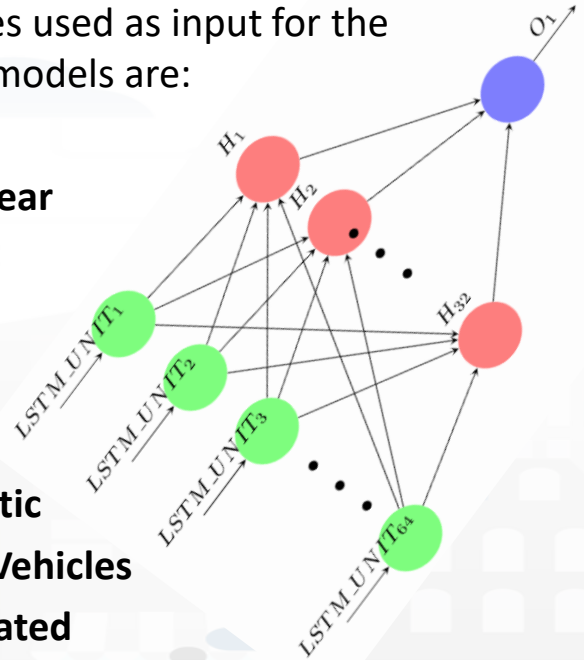


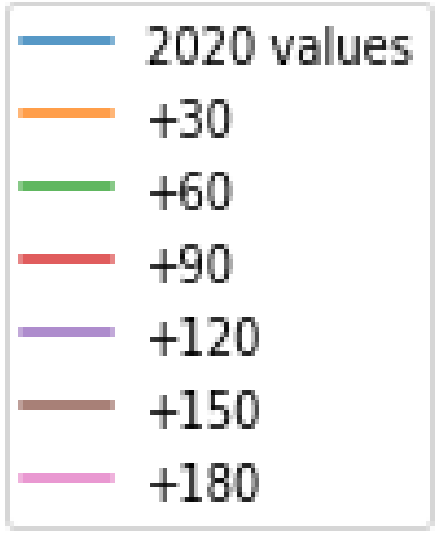
Predicting EC's KPI on NO2 months in advance

Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance



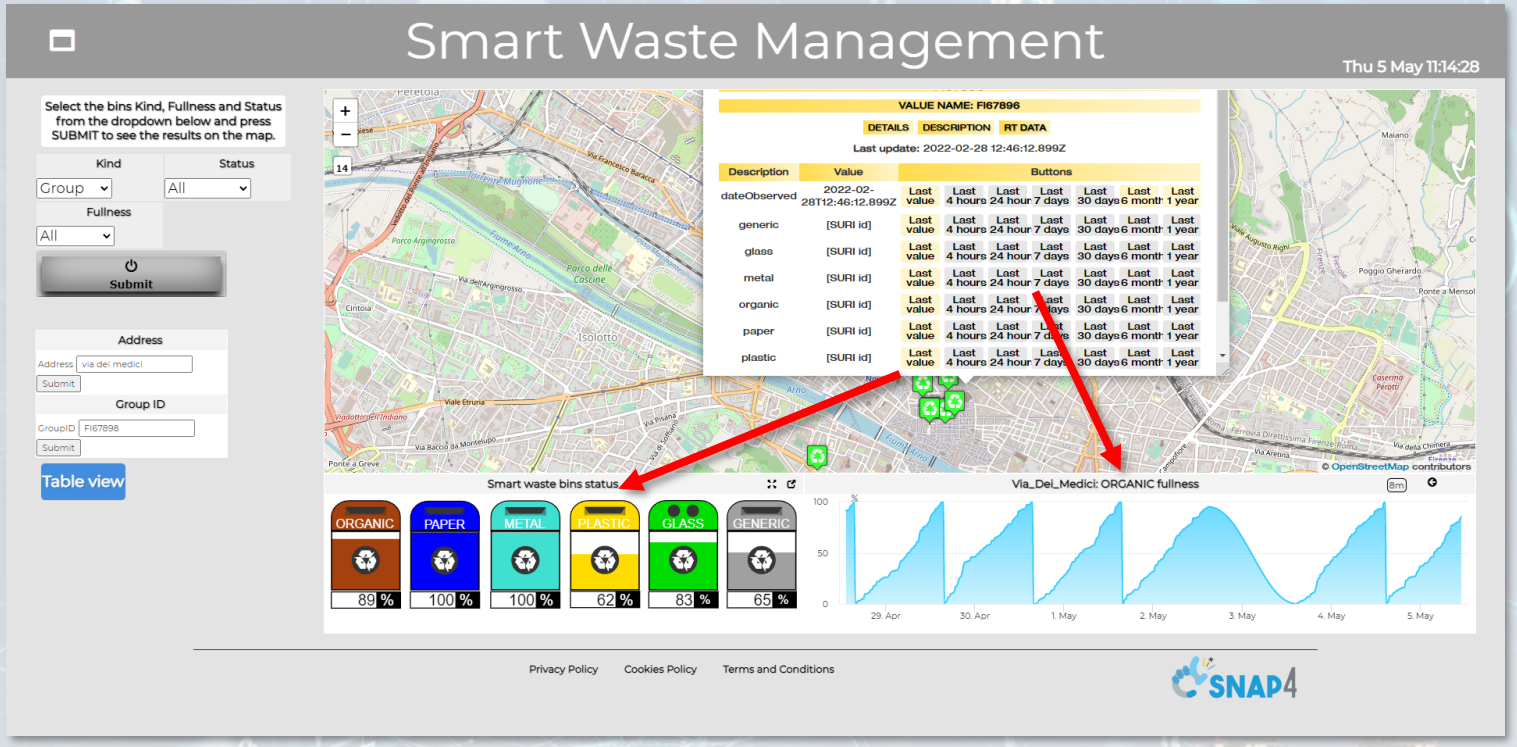
- The features used as input for the predictive models are:
- **Month**
- **dayOfTheYear**
- **NO2**
- **Tmean**
- **Humidity**
- **windMean**
- **NoxDomestic**
- **numberOfVehicles**
- **NO2cumulated**
- **NO2progresseveMean**
- **numberOfVehiclesCumulated**





	Air Quality Directive			WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	One day			25 µg/m³ (*)	99th percentile (3 days/year)
$PM_{2.5}$	Calendar year	Target value, 25 µg/m³	The target value has become a limit value since 1 January 2015	10 µg/m³	
PM_{10}	One day	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year.	50 µg/m³ (*)	99th percentile (3 days/year)
PM_{10}	Calendar year	Limit value, 40 µg/m³ (*)		20 µg/m³	
O_3	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO_2	One hour	Limit value, 200 µg/m³ (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)	
NO_2	Calendar year	Limit value, 40 µg/m³		40 µg/m³	

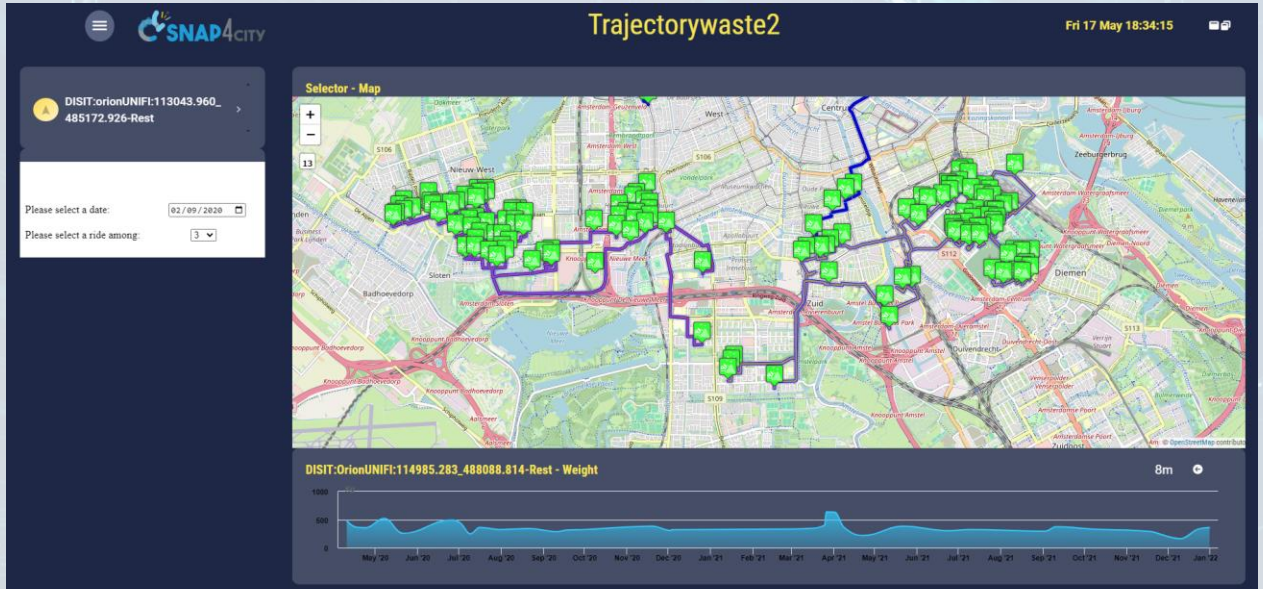
Smart Waste – Map view

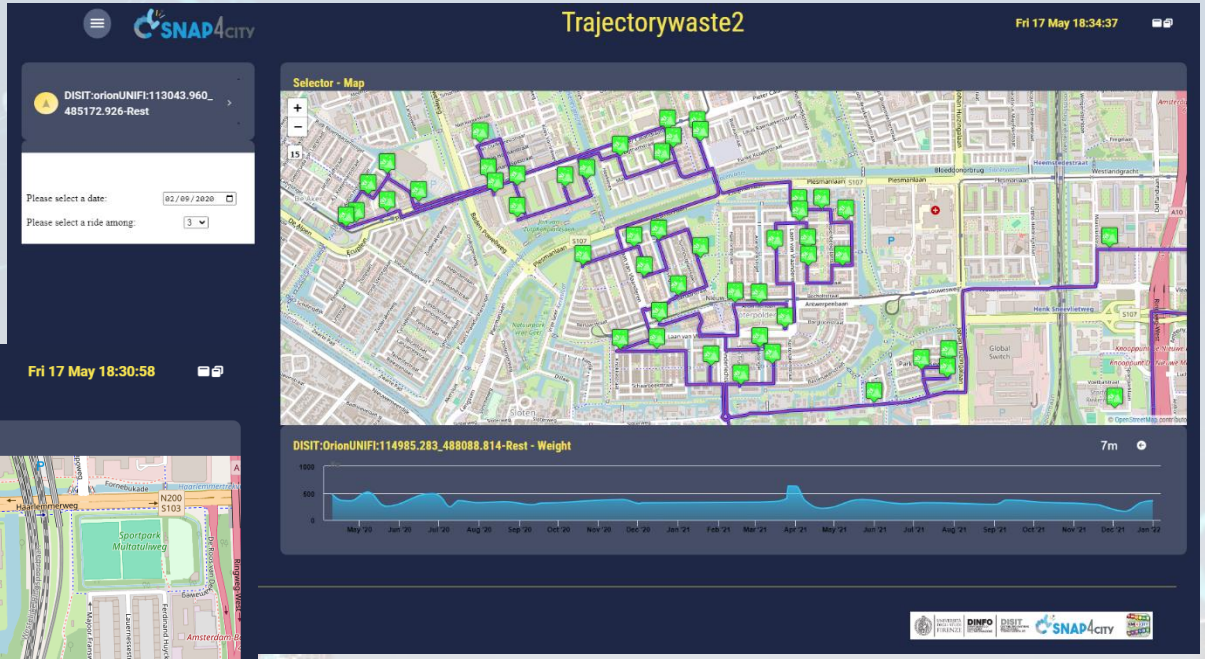


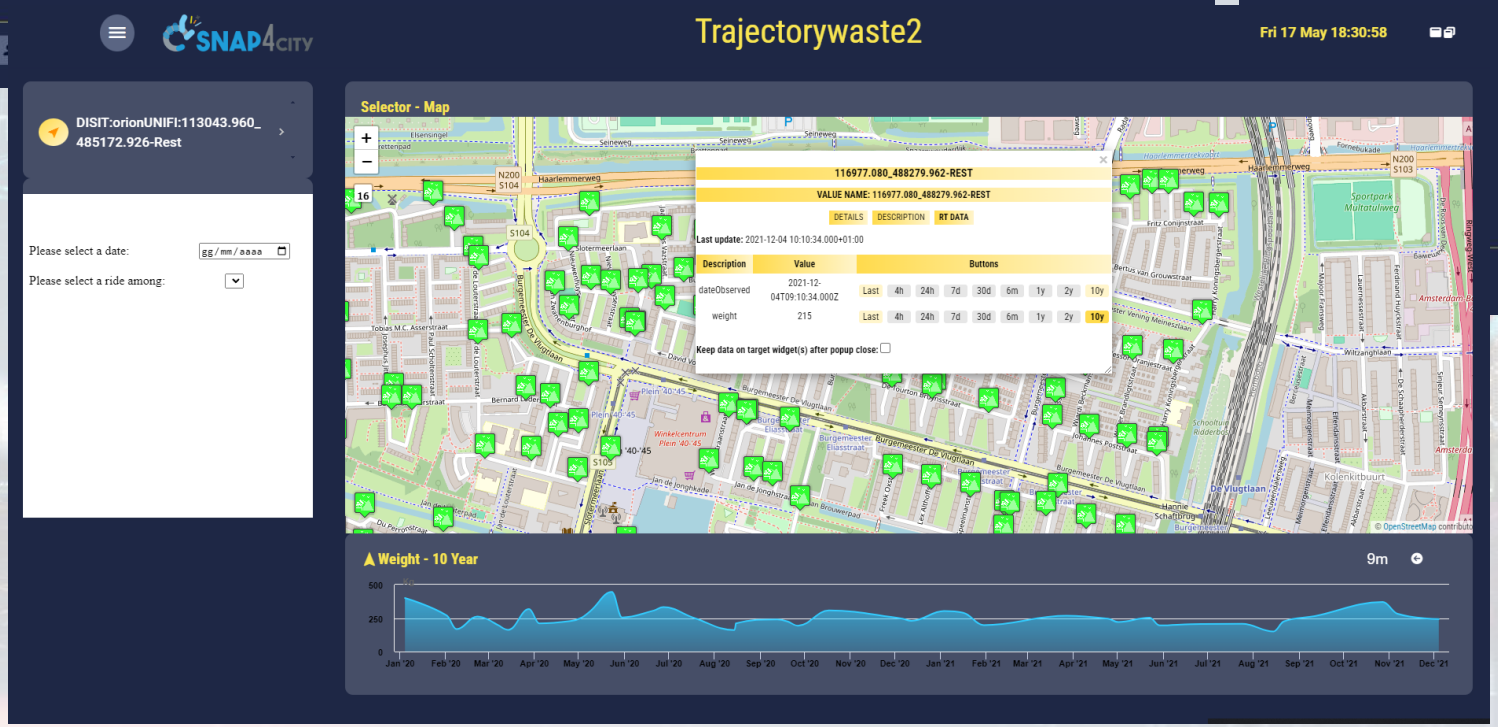
Search bins on map by filtering per:

- **Kind** (All, generic, plastic, paper, glass, metal, organic)
- **Status** (Active, Not Active)
- **Fullness** (Full, Half-full, Empty)
- **Address**
- **Group of bins** (by GroupID)

- Reduction of costs for waste collection
  - Optimization of waste collection for the next day, forecast
  - Production of rides and paths for the drivers on waste collection
- Operator:
  - Refine a search by using the filters on the left side
  - Click on a waste bin pin on the map:
  - A popup with real time data is shown
  - The fullness status of the selected group of bins is shown in the synoptic below the map
  - Specific fullness weekly trends are shown below the map
  - Chick on the «Table view» button to access the other dashboard


Trajectorywaste2
Fri 17 May 18:34:15
DISIT:orionUNIFI:113043.960_485172.926-Rest
Please select a date:
02/09/2020
Please select a ride among:
3
Selector - Map
DISIT:OrionUNIFI:114985.283_488088.814-Rest - Weight
8m


Trajectorywaste2
Fri 17 May 18:34:37
DISIT:orionUNIFI:113043.960_485172.926-Rest
Please select a date:
02/09/2020
Please select a ride among:
3
Selector - Map
DISIT:OrionUNIFI:114985.283_488088.814-Rest - Weight
7m

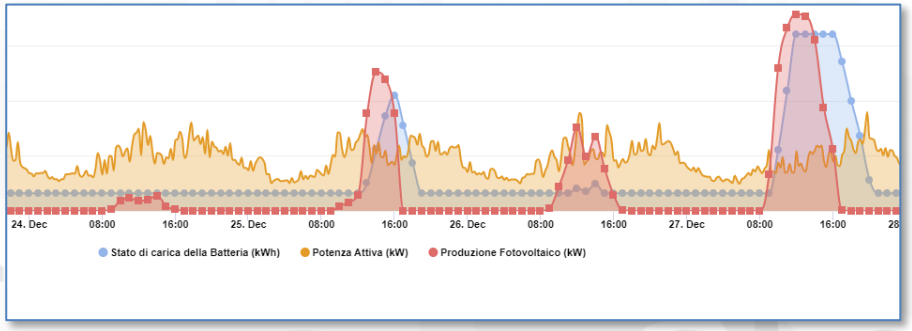

Trajectorywaste2
Fri 17 May 18:30:58
DISIT:orionUNIFI:113043.960_485172.926-Rest
Please select a date:
gg/mm/aaaa
Please select a ride among:
Selector - Map
116977.080_488279.962-REST
VALUE NAME: 116977.080_488279.962-REST
DETAILS
DESCRIPTION
RT DATA
Last update: 2021-12-04 10:10:34.000+01:00
Description
Value
Buttons
dateObserved
2021-12-04T09:10:34.000Z
weight
215
Keep data on target widget(s) after popup close:
Weight - 10 Year
9m


11
SUSTAINABLE CITIES AND COMMUNITIES

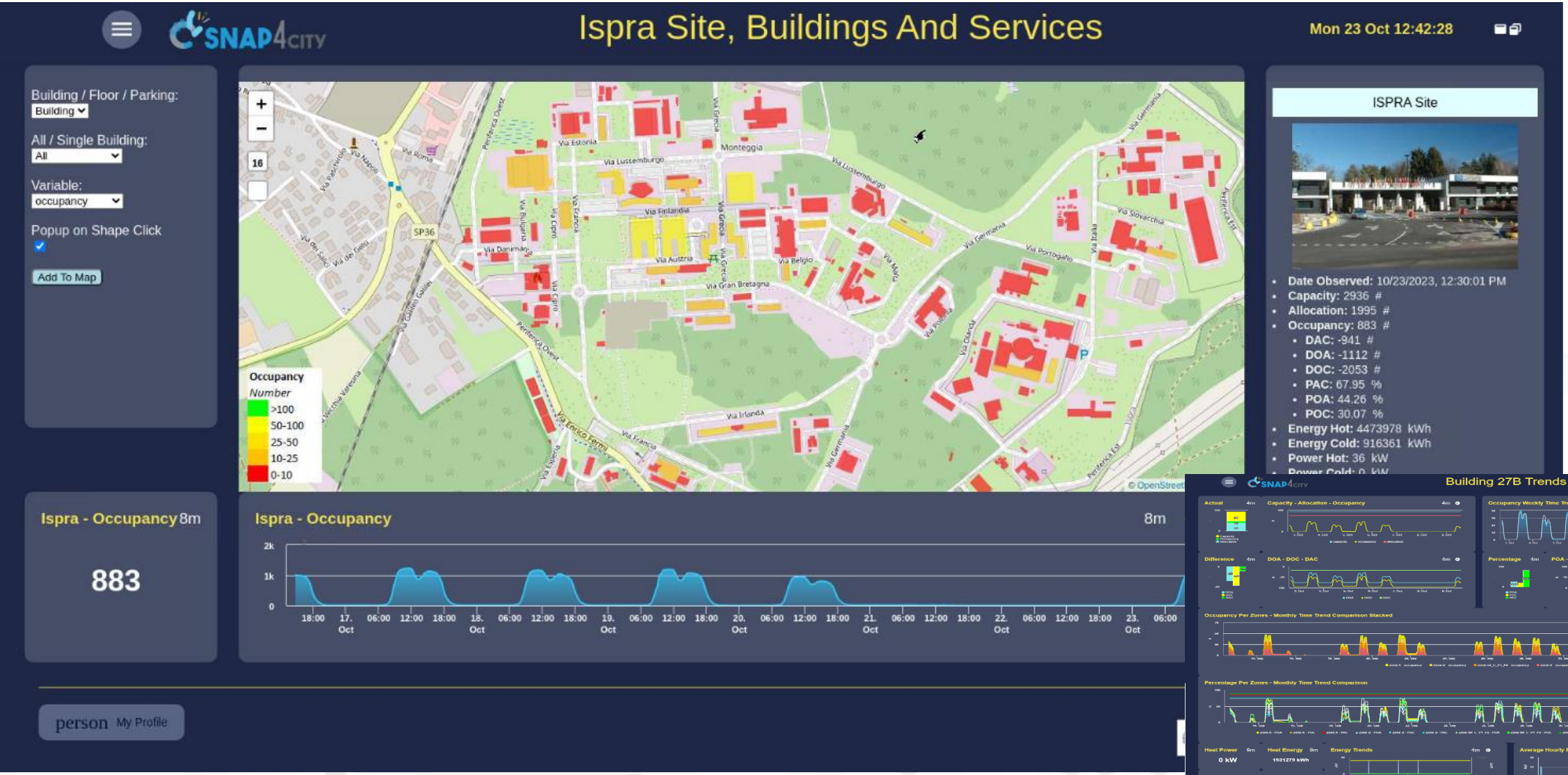

3
GOOD HEALTH AND WELL-BEING

City Energy and Buildings

- **Goals:**
  - Energy consumption reduction, increment of efficiency,
  - Areas and building sustainability
  - Improve accessibility to services, security and safety
- **Energy Monitoring:** Building, floors, rooms, recharging poles, cabinets, Community of Energy, Data centers, Energy for Hot / cold, air condition, energy vs temperature and usage, etc.
- **Energy Management:** Predictions, early warning, identification of critical conditions
- **Smart Light Management**: LED/mixt, cabinets, lights vs traffic, lights vs security, energy saving, luminaries profiling, group management.
- **Smart Building Management:** consumption, number of people, etc.
  - Communities of Energy, Photovoltaic plants, sustainability
  - What-if analysis, optimisation tools
- **KPI: Energy consumption, efficiency, pros/cons**
  - Light profiling and adaptation
  - Autoclave industrial plants simulation, Photovoltaic plant simulation
  - consumption / usage, energy vs temperature
- **Mobile App:** monitoring, info-recharge, eSharing, booking, ..
- **Participatory**: problem reporting, ticketing, etc.
- **Integration of any kind**

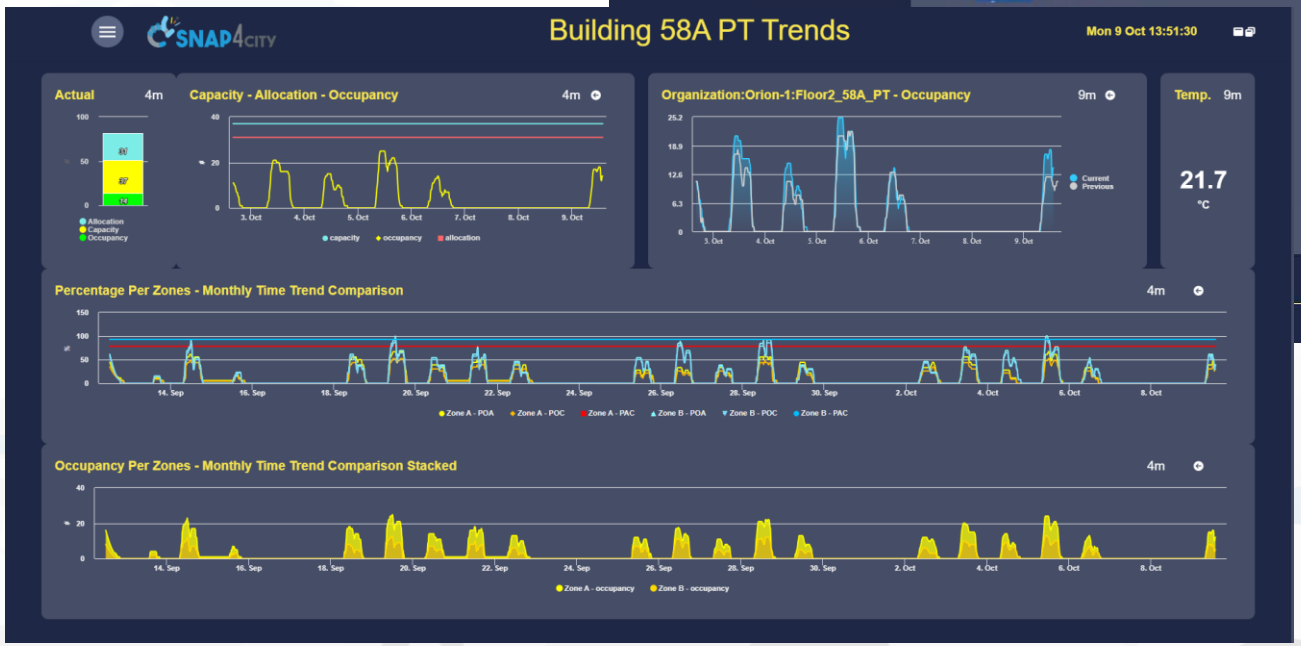


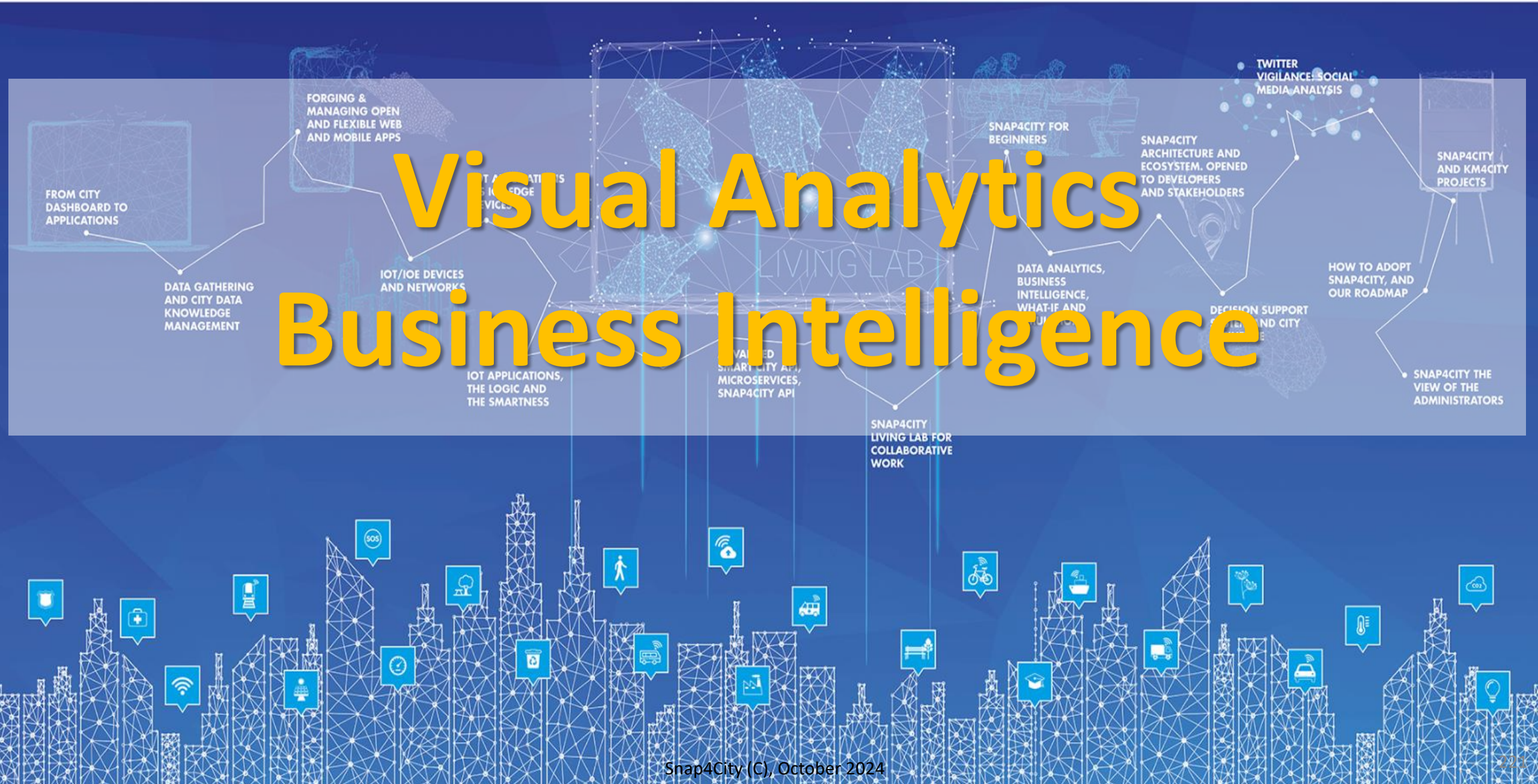
ISPRA JRC Site



Floor Details

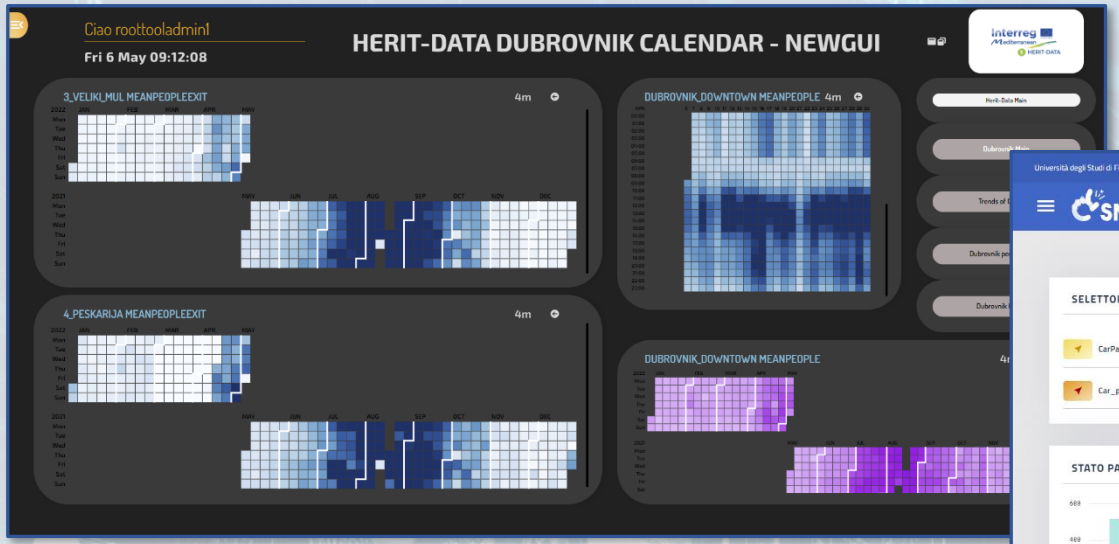
ISPRA JRC Site

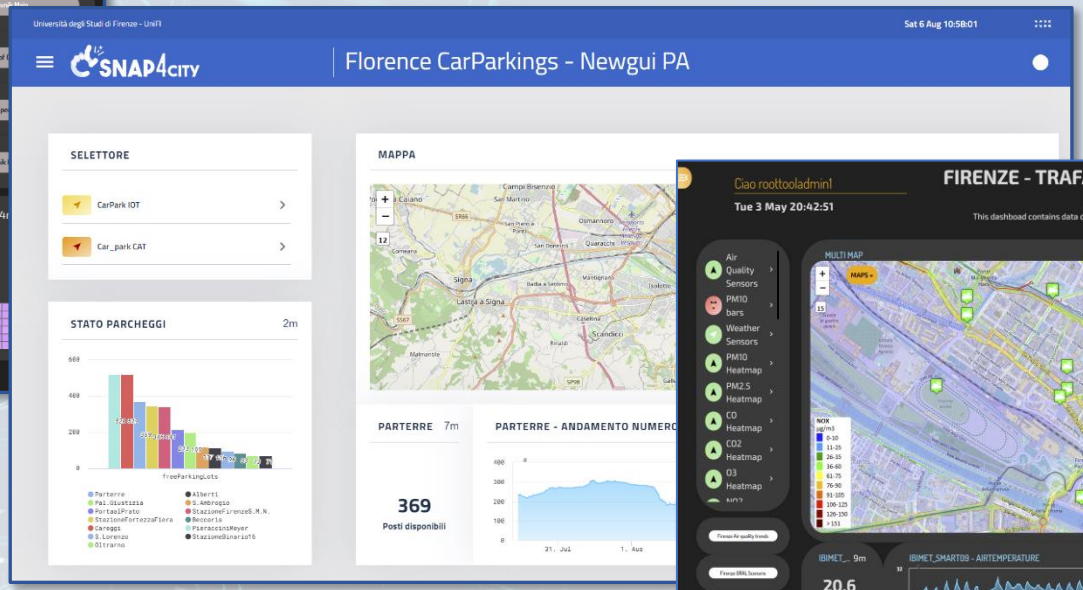


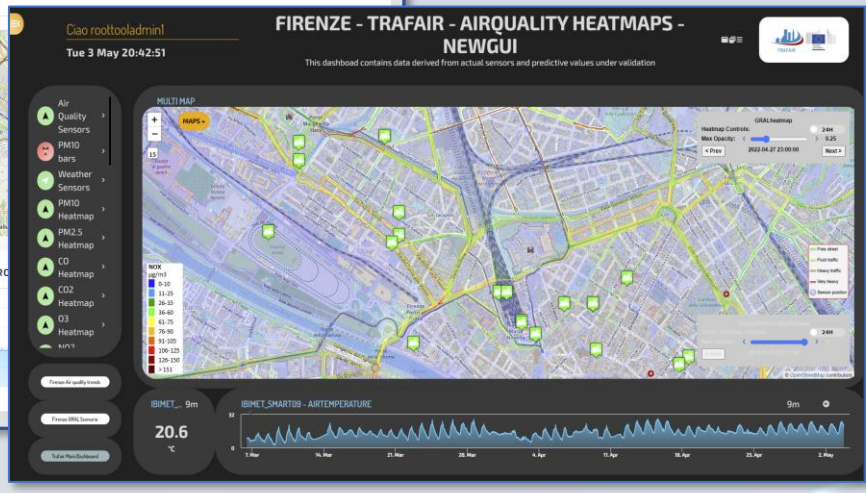


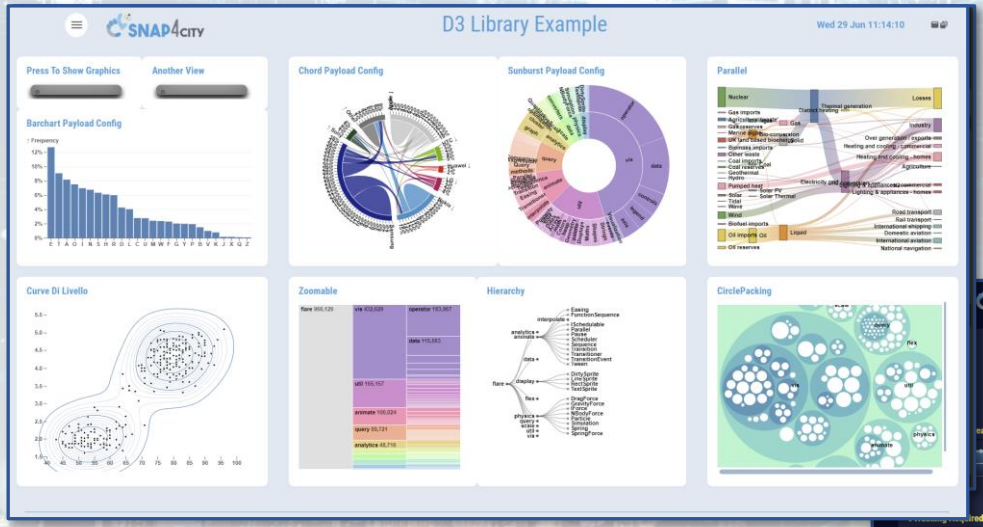
Visual Analytics Business Intelligence

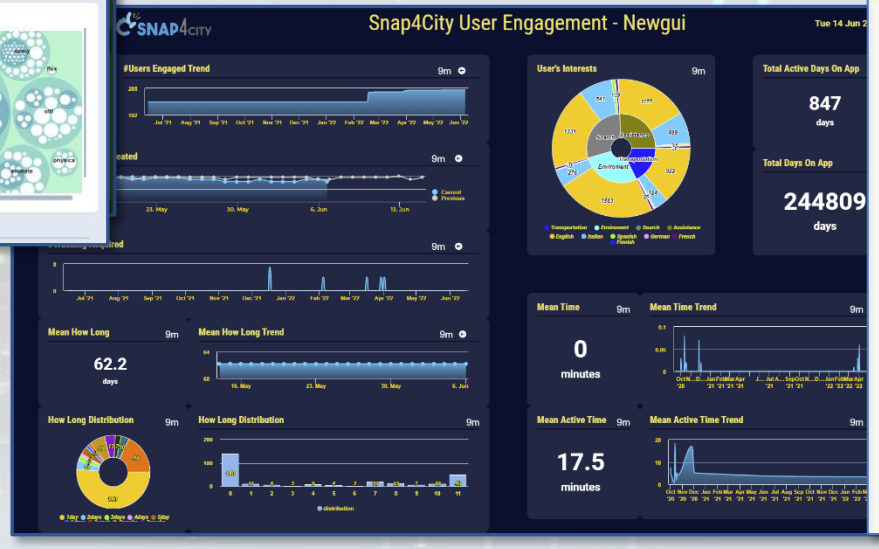
Different Themes

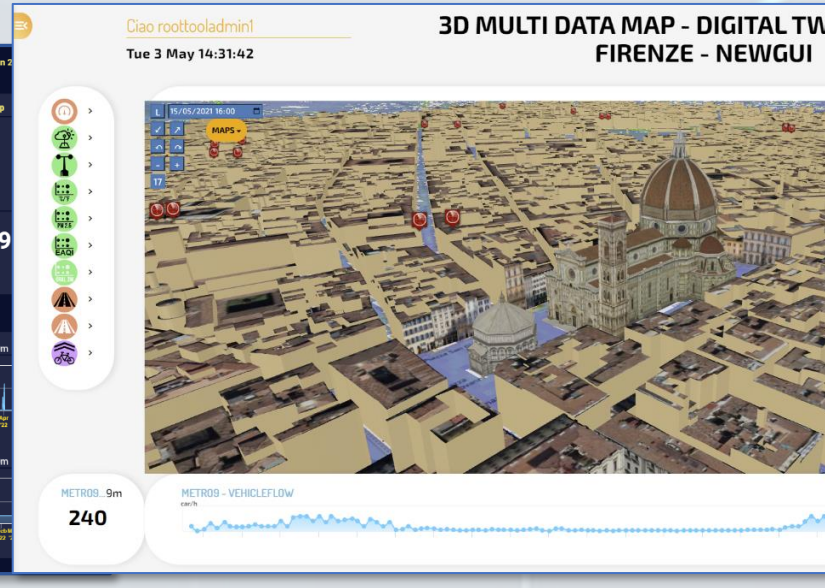










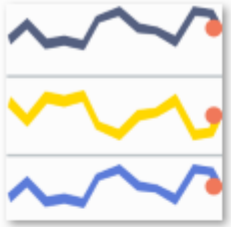


New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

Visual Representations


Sliderwith-multiple-steps-for-KPI


sparklines

kpi


histogram


heatmap


flow-maps


geo-maps

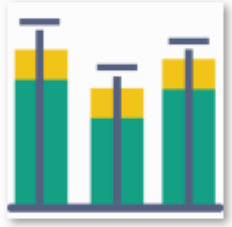

donut-chart

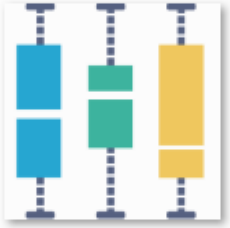

Data-grid


chord


Cone


Bubble-matrix-chart


Bullet


Box-plot


staked-area


Stacked-line-chart


Stacked-combinational-Chart


spider-maps


Sequence-Sunbur


Pivot


pie-chart-1


Pareto-chart


radar

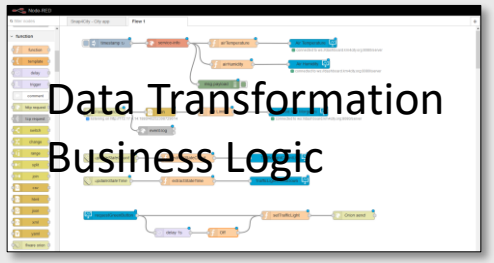

Bubble-maps


waterfall


Sunburst


Sankey

Dashboard Builder: Development



Data Transformation
Business Logic

IOT Applications

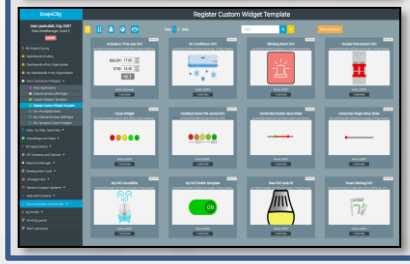
Knowledge Base,
Km4City

Knowledge and Storage
Data from the Field and
City + MyKPI ++

Widget Collection

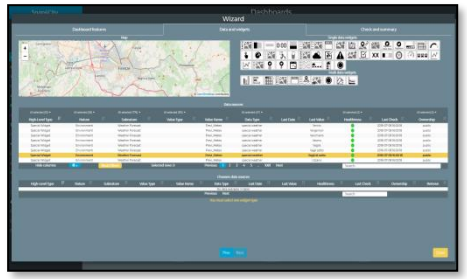
Micro
Applicat
ions

External
Services

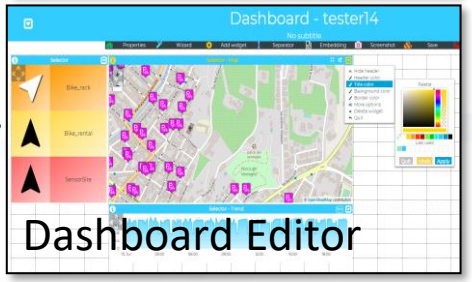


Custom
Widgets/
Synoptics

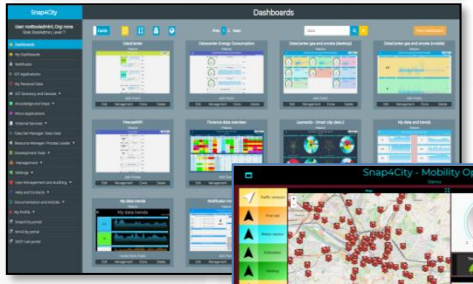
Dashboard Wizard

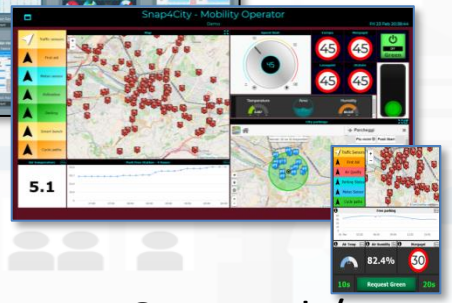


Create, save, load,
delegate, grant access,
change ownership



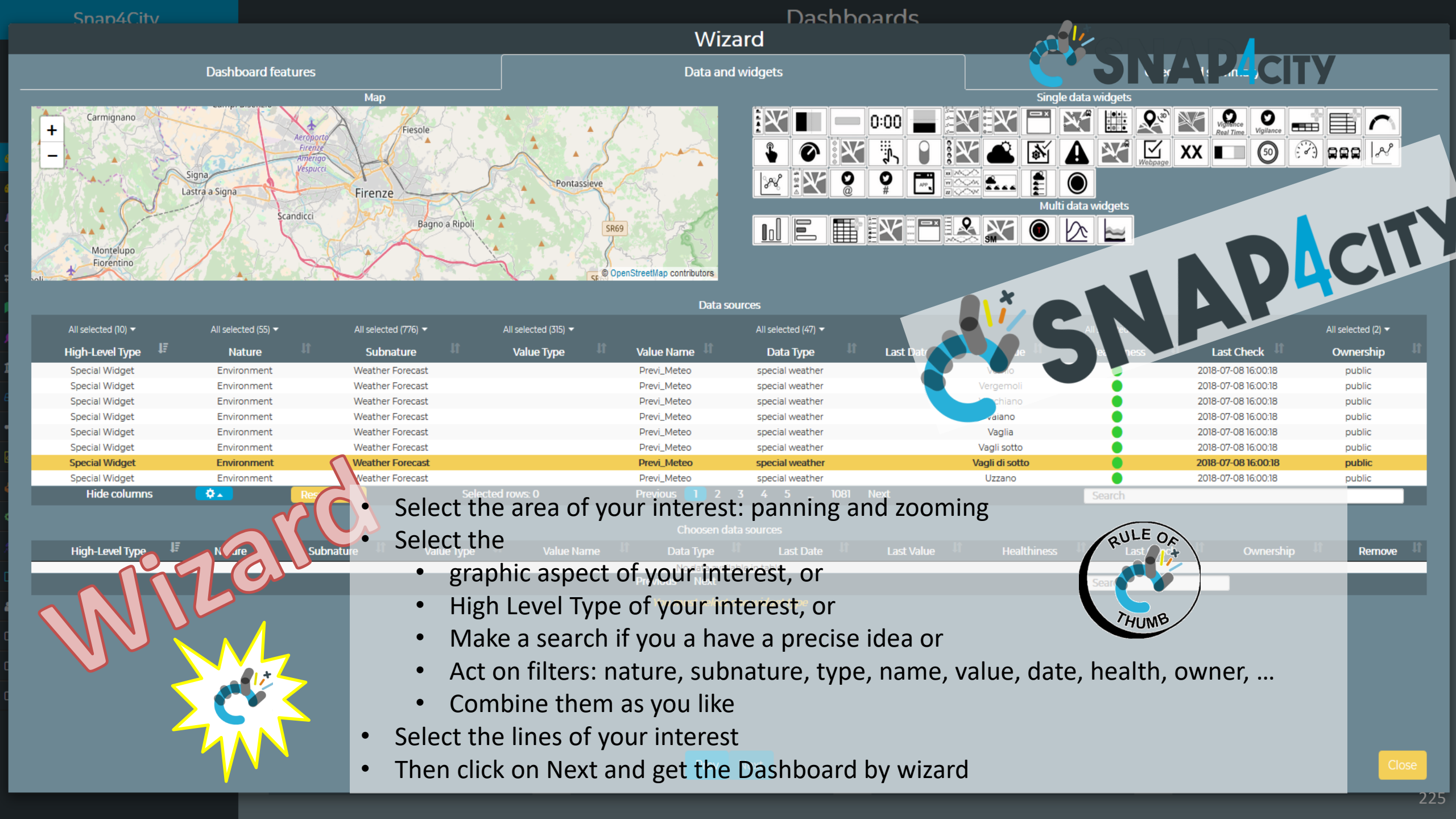
Dashboard Editor





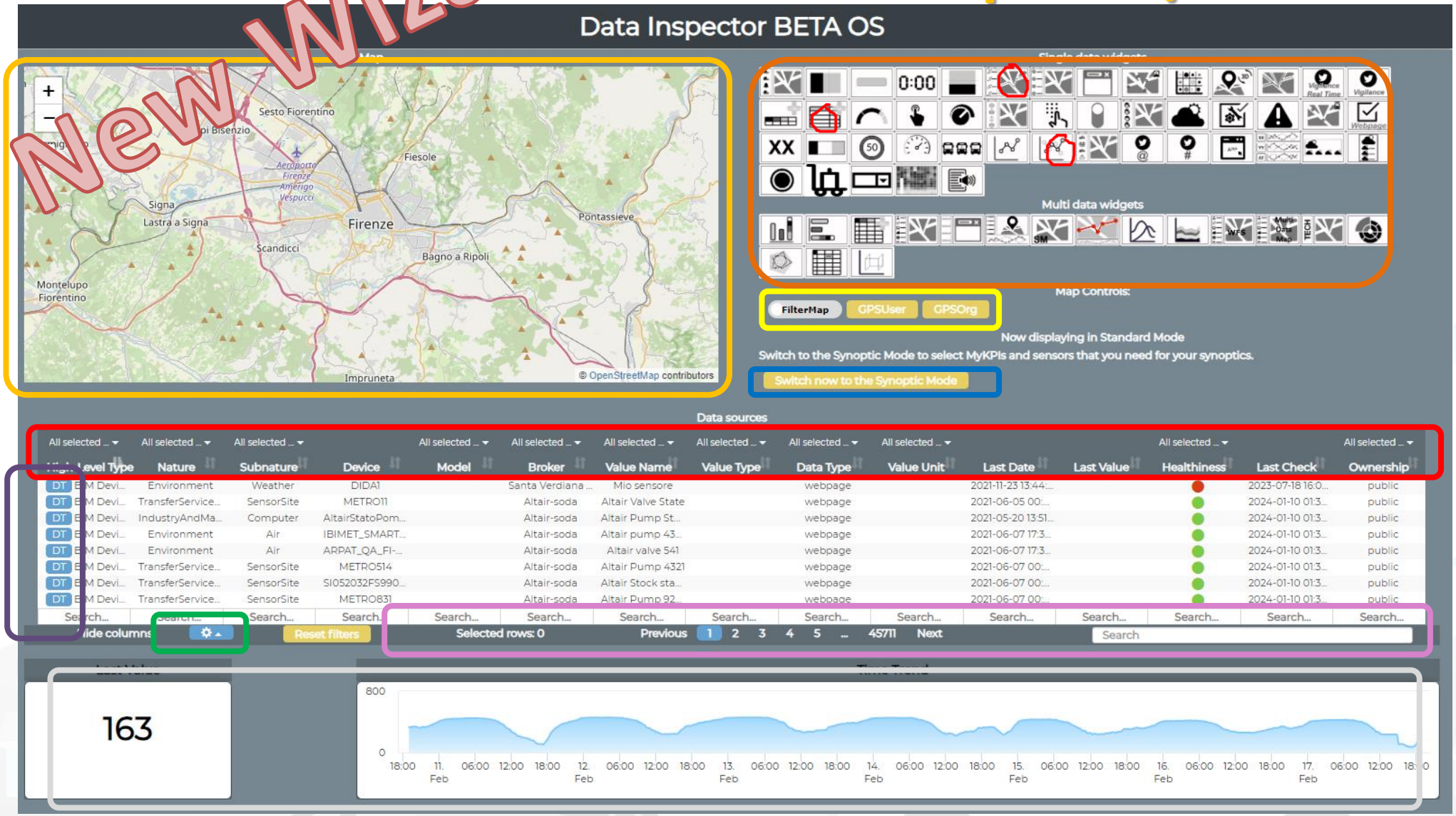
Public
Dashboard
Collection

My Own Dash/App


Wizard
Dashboard features
Data and widgets
Map
Single data widgets
Multi data widgets
Data sources
Wizard
Select the area of your interest: panning and zooming
Select the
graphic aspect of your interest, or
High Level Type of your interest, or
Make a search if you a have a precise idea or
Act on filters: nature, subnature, type, name, value, date, health, owner, …
Combine them as you like
Select the lines of your interest
Then click on Next and get the Dashboard by wizard
RULE OF THUMB
Close

New Data Inspector/Wizard

New Wizard



Filtering/Searching for individual fields (even for some fields not displayed as geographic coordinates)

Geographic Filtering

Text Search on all fields

Menu for choosing the fields to display in the table

View on Map(via PREVIEW)

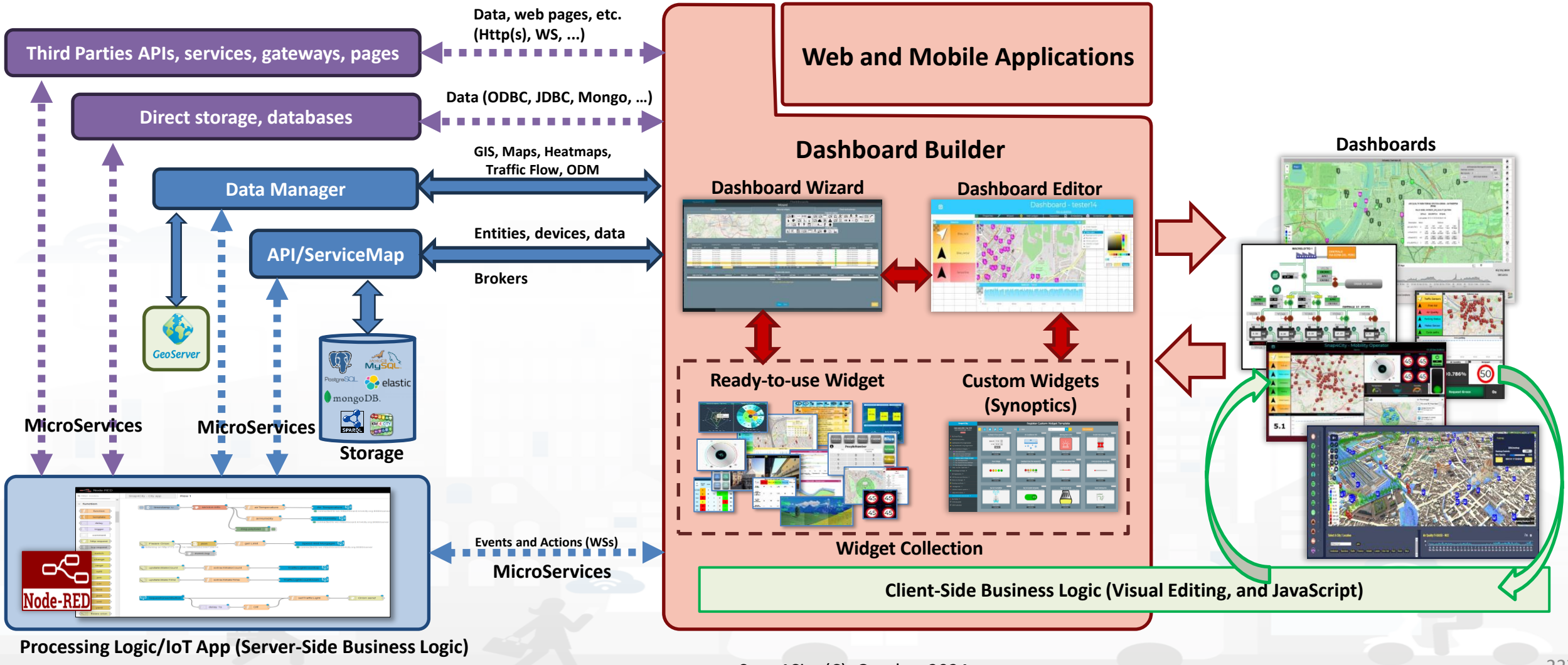
Data and Trend visualization

Opening Digital Twin

Pass to Synoptic mode

Select the graph representation

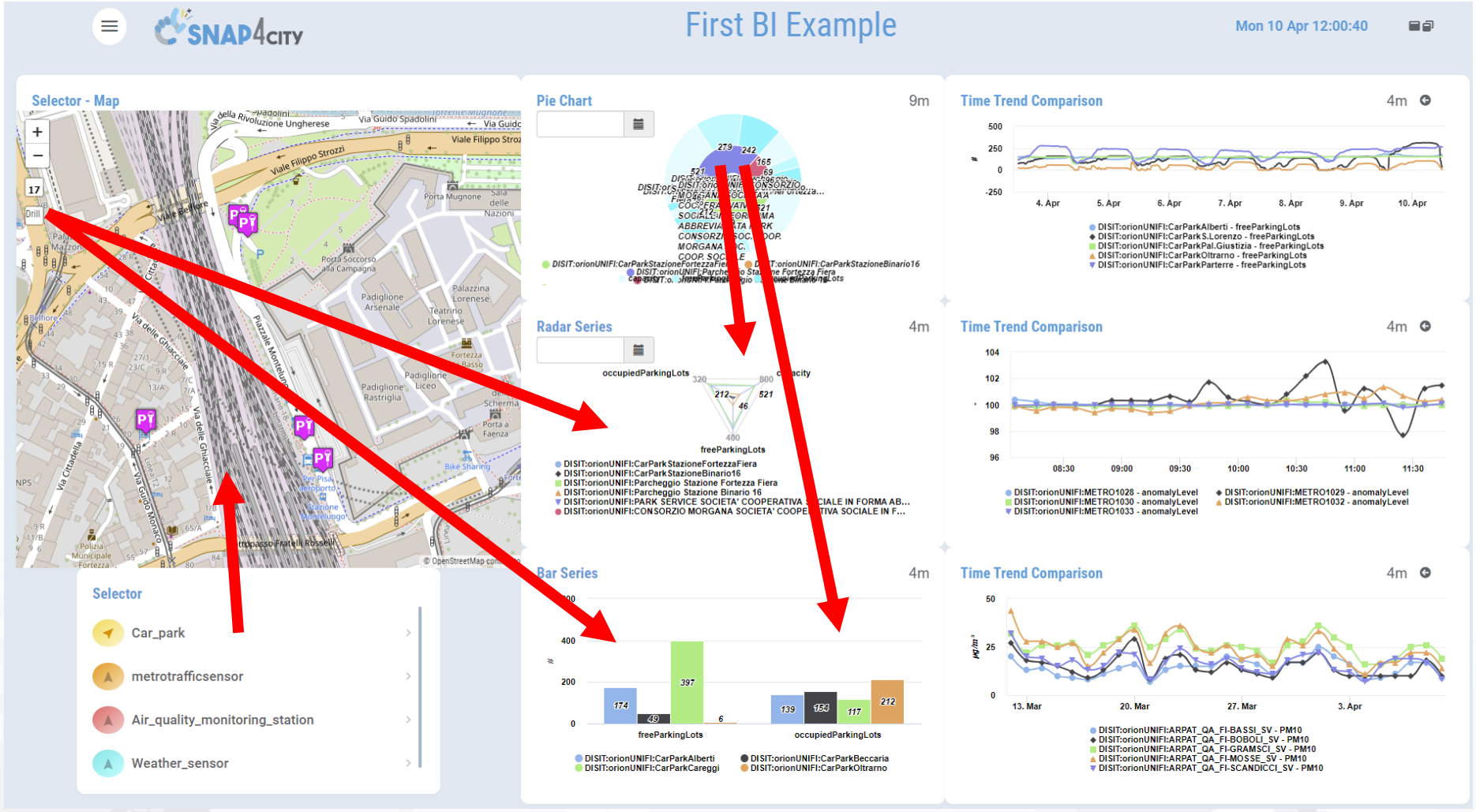
How the Dashboards / Apps Exchange data (2024/8)



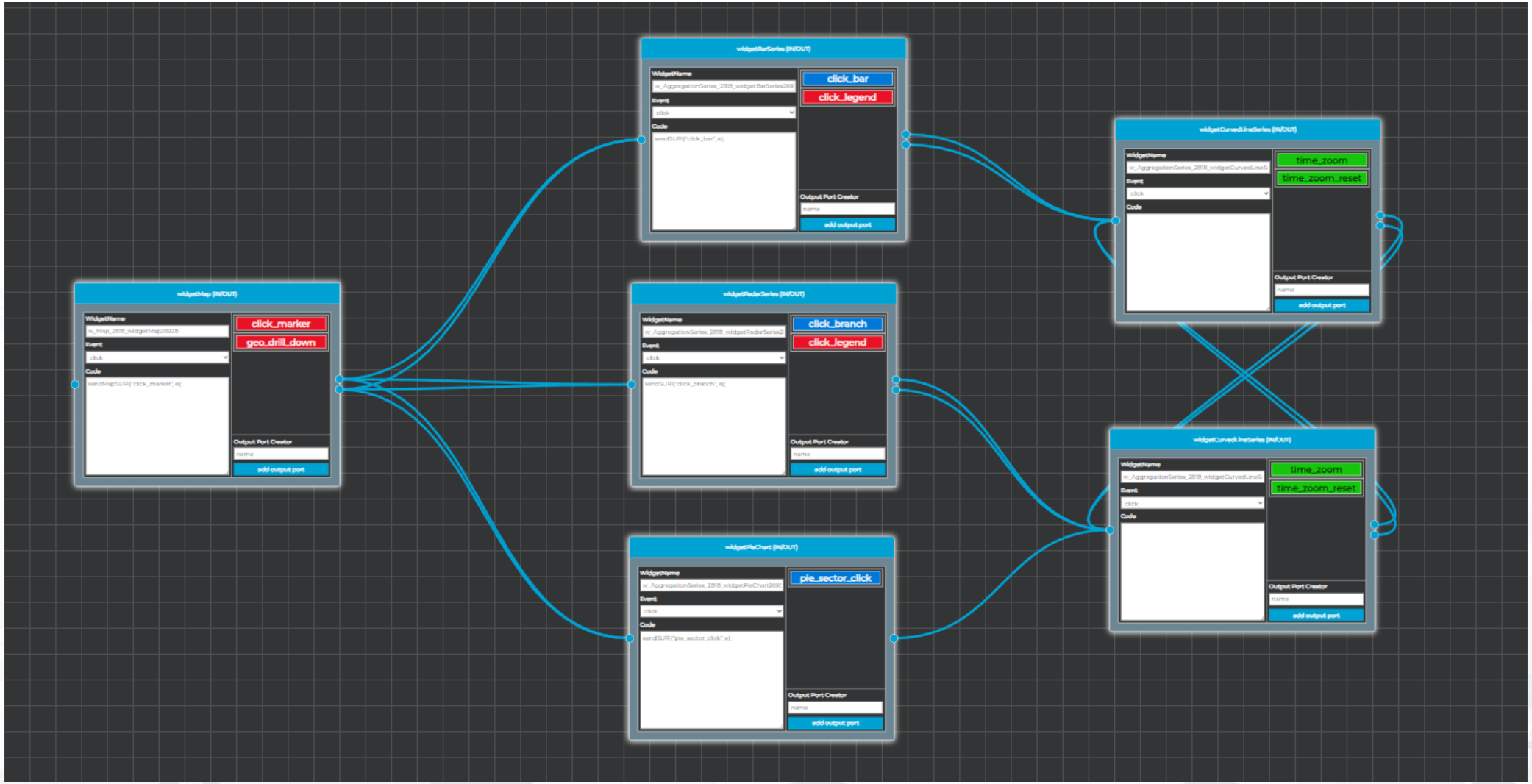
Example: From Map to Graphs (spatial drill down)

1) Select the area of interest on map
2) Select the sensors kind of interest
3) Drill down on map

4) The JavaScript CSBL on Map will send data to the programmed Widgets. In this case, arrowed in RED

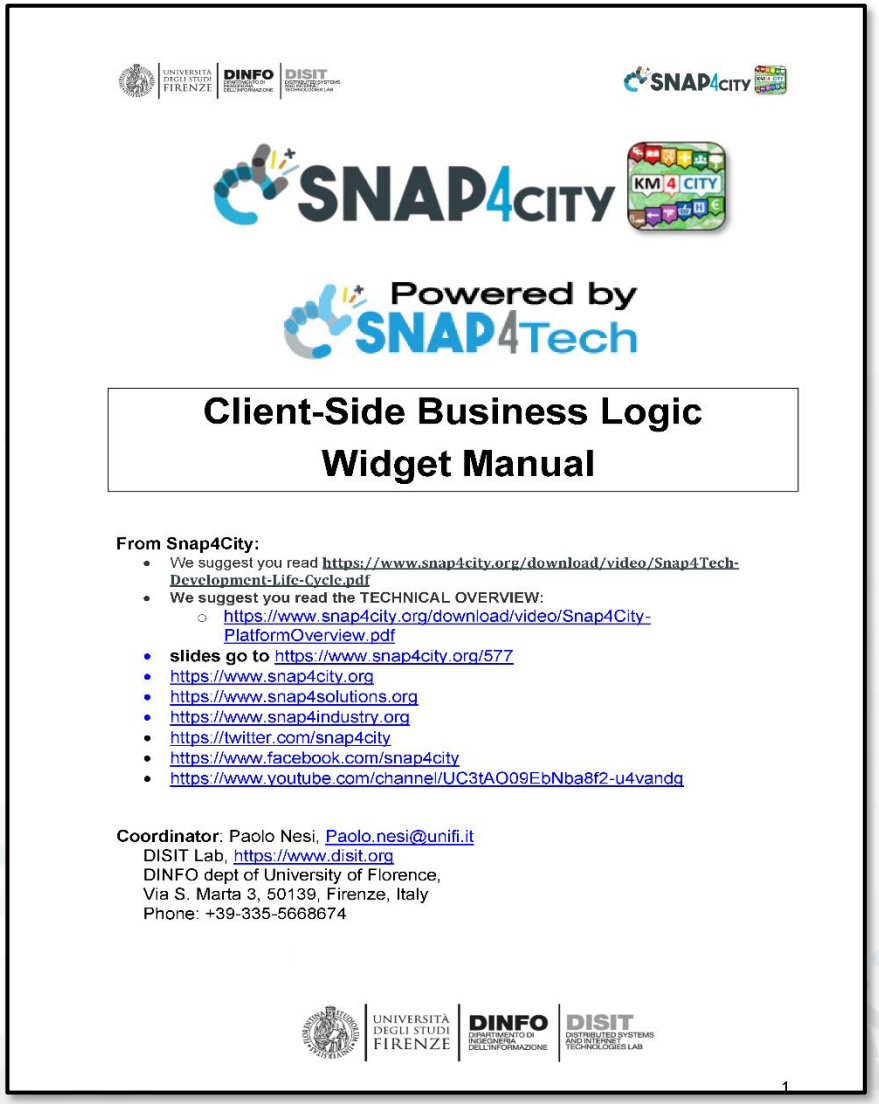


Visual programming for CSBL, accessible in beta



CSBL

Client Side Business Logic



Powered by SNAP4Tech

Client-Side Business Logic
Widget Manual

From Snap4City:

- We suggest you read **https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf**
- **We suggest you read the TECHNICAL OVERVIEW:**
  - https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf
- **slides go to** https://www.snap4city.org/577
- https://www.snap4city.org
- https://www.snap4solutions.org
- https://www.snap4industry.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAQ09EbNba8f2-u4vandg

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Phone: +39-335-5668674

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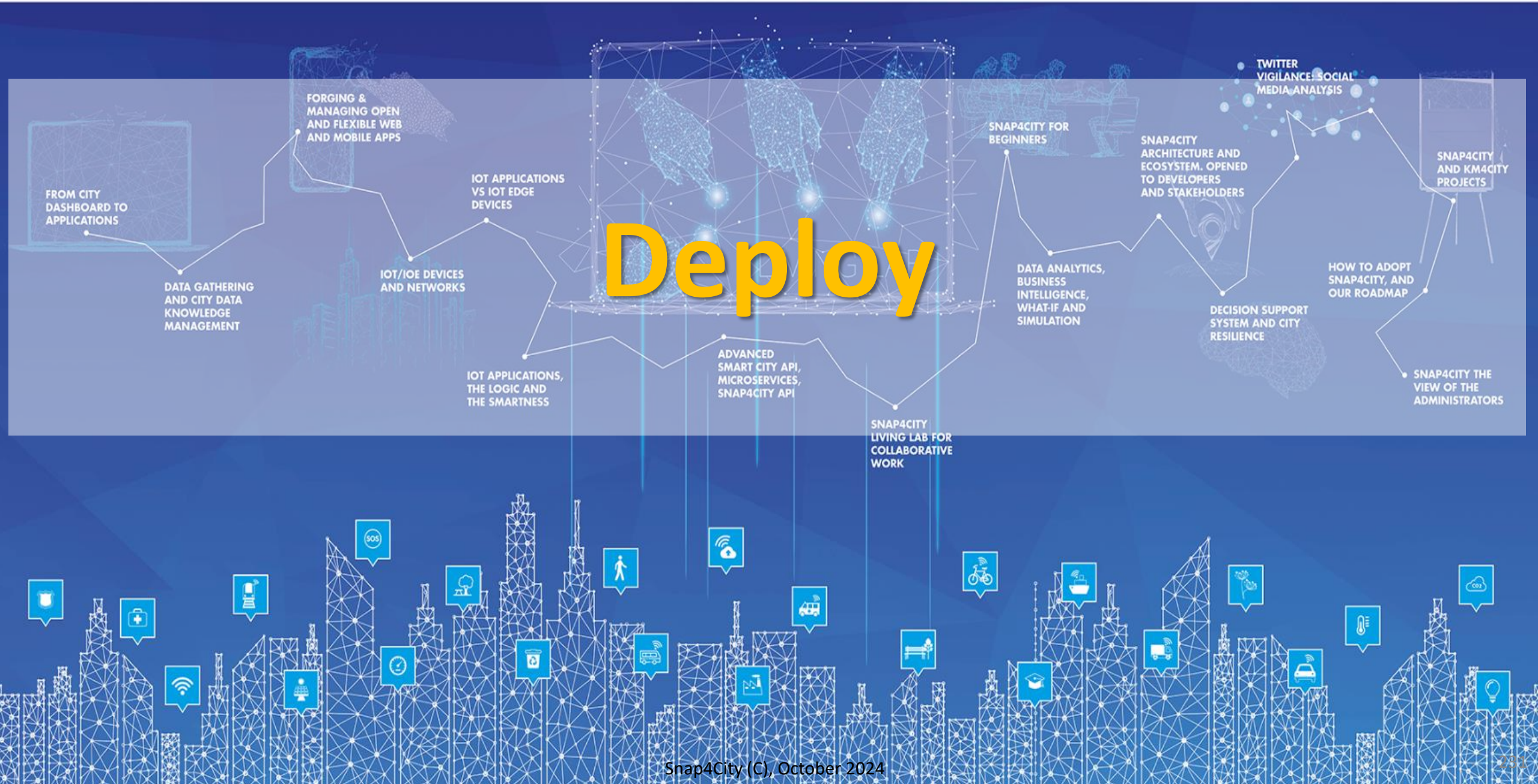
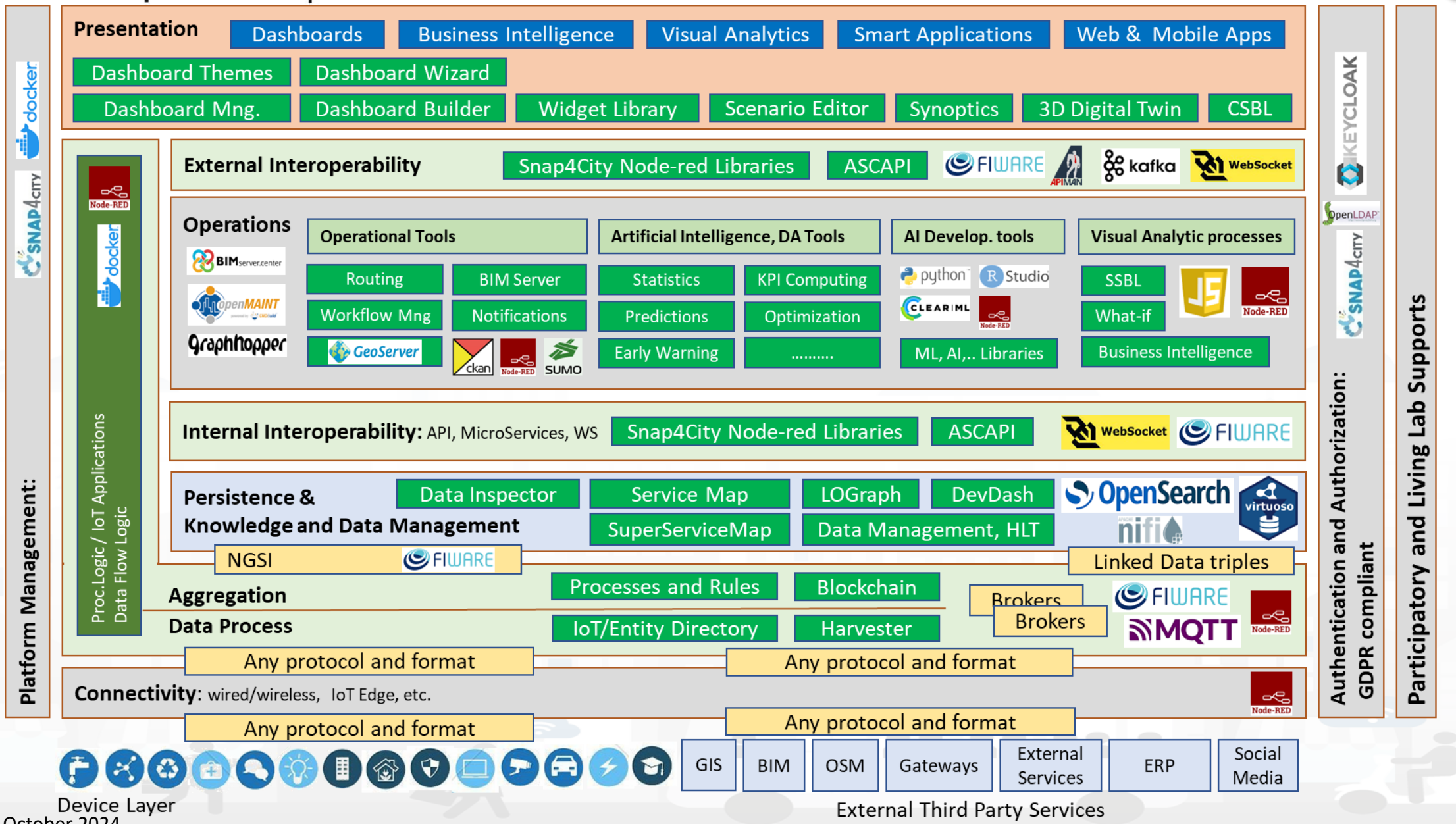
https://www.snap4city.org/download/video/ClientSideBusinessLogic-WidgetManual.pdf

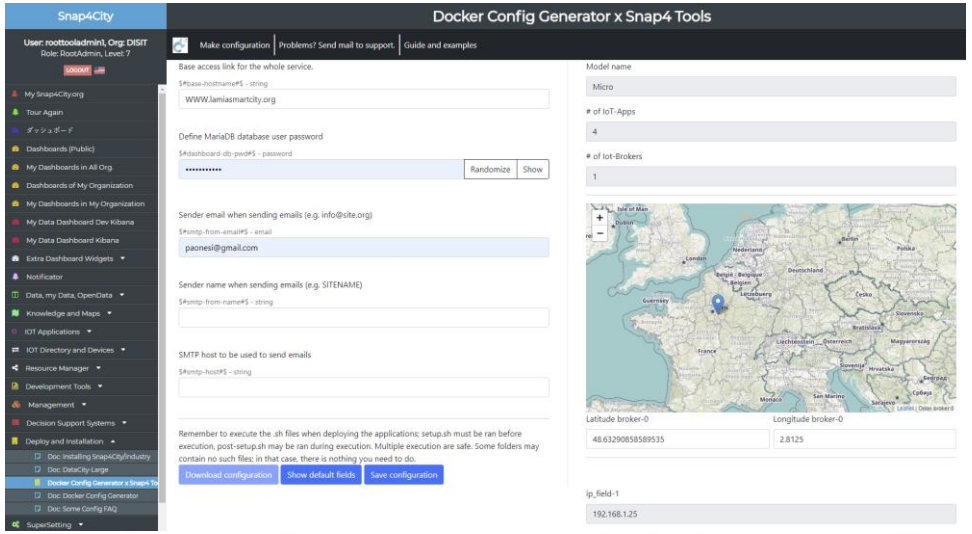
SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

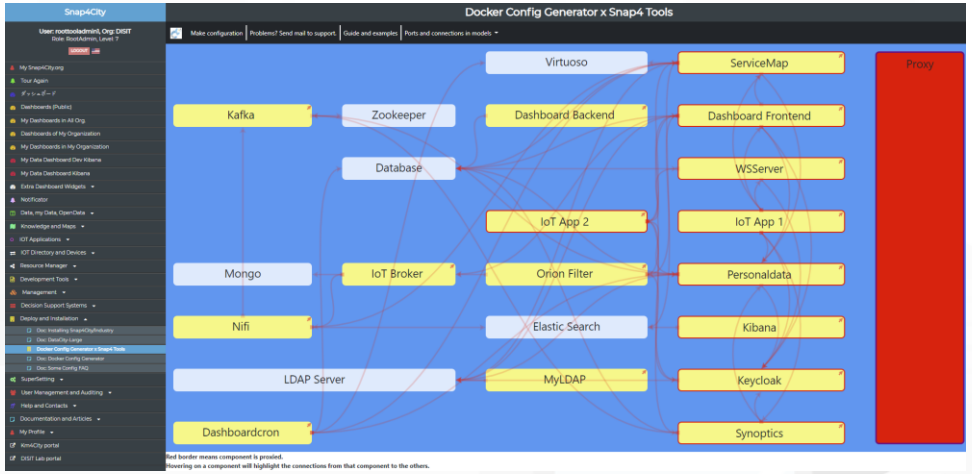



Platform Management:
Presentation
Dashboards
Business Intelligence
Visual Analytics
Smart Applications
Web & Mobile Apps
Dashboard Themes
Dashboard Wizard
Dashboard Mng.
Dashboard Builder
Widget Library
Scenario Editor
Synoptics
3D Digital Twin
CSBL
External Interoperability
Snap4City Node-red Libraries
ASCAPI
FIWARE
kafka
WebSocket
Operations
Operational Tools
Routing
BIM Server
Workflow Mng
Notifications
GeoServer
Artificial Intelligence, DA Tools
Statistics
KPI Computing
Predictions
Optimization
Early Warning
.....
AI Develop. tools
python
R Studio
CLEARML
ML, AI,.. Libraries
Visual Analytic processes
SSBL
What-if
Business Intelligence
Node-RED
Proc.Logic / IoT Applications
Data Flow Logic
Internal Interoperability: API, MicroServices, WS
Snap4City Node-red Libraries
ASCAPI
WebSocket
FIWARE
Persistence & Knowledge and Data Management
Data Inspector
Service Map
LOGraph
DevDash
SuperServiceMap
Data Management, HLT
OpenSearch
virtuoso
nifi
NGSI
FIWARE
Linked Data triples
Aggregation
Data Process
Processes and Rules
Blockchain
IoT/Entity Directory
Harvester
Brokers
Brokers
FIWARE
MQTT
Any protocol and format
Any protocol and format
Connectivity: wired/wireless, IoT Edge, etc.
Any protocol and format
Any protocol and format
Device Layer
GIS
BIM
OSM
Gateways
External Services
ERP
Social Media
External Third Party Services
KEYCLOAK
OpenLDAP
Authentication and Authorization: GDPR compliant
Participatory and Living Lab Supports

Installations, different models a TOOL to get them

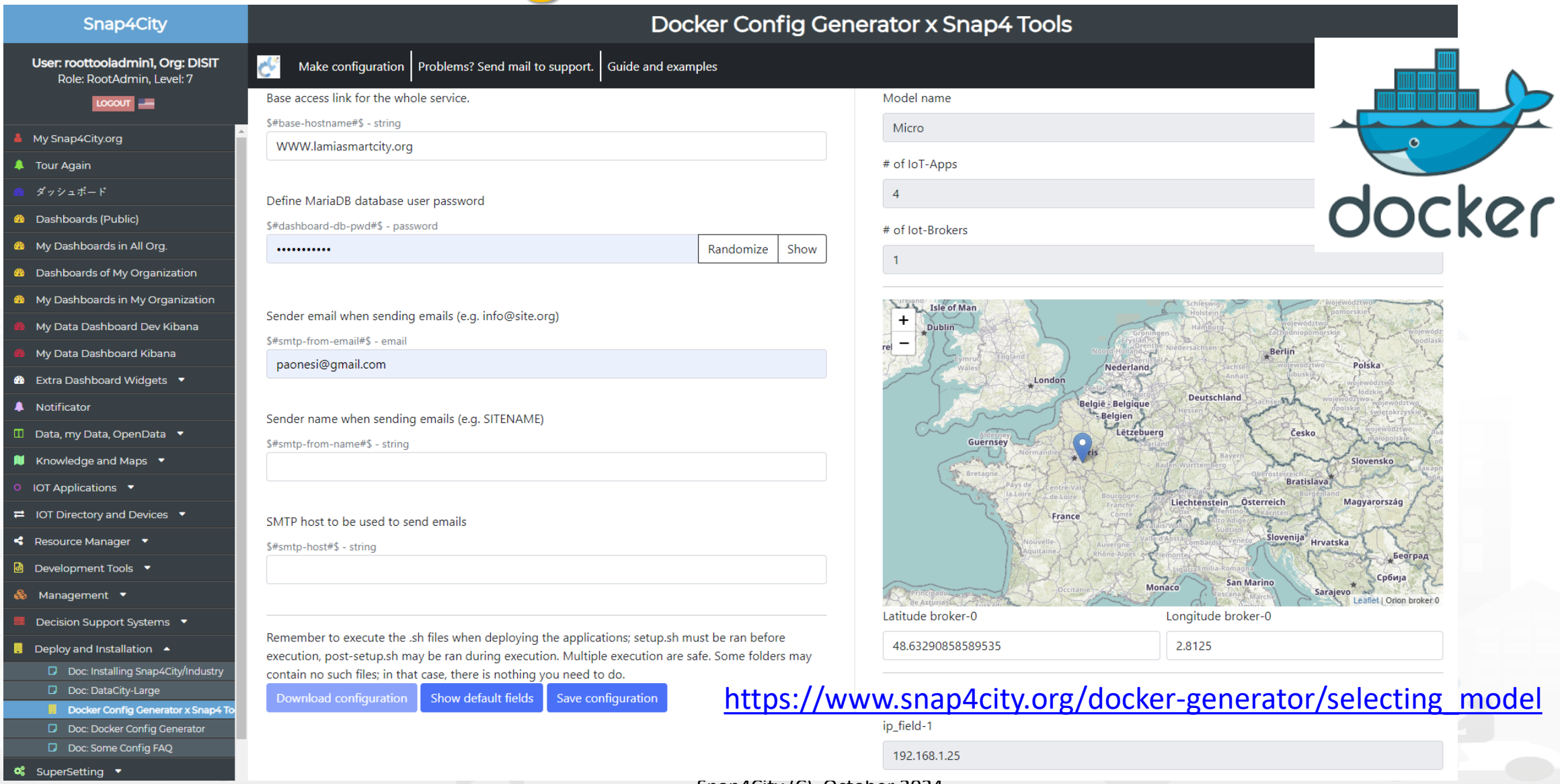
- Micro X:
  - 1 VM of dockers
- Normal X,Y:
  - 2 VM of dockers
- Small X,Y: scalable
  - 4 VM of dockers
- DataCitySmall X,Y,Z: scalable
  - 6 VM of dockers
- DataCityMid X,Y,Z,T: scalable
  - # VM + X/70 VM + Y/3 VM + Z VM + T VM of dockers
- DataCityLarge: scalable
  - depending on your needs



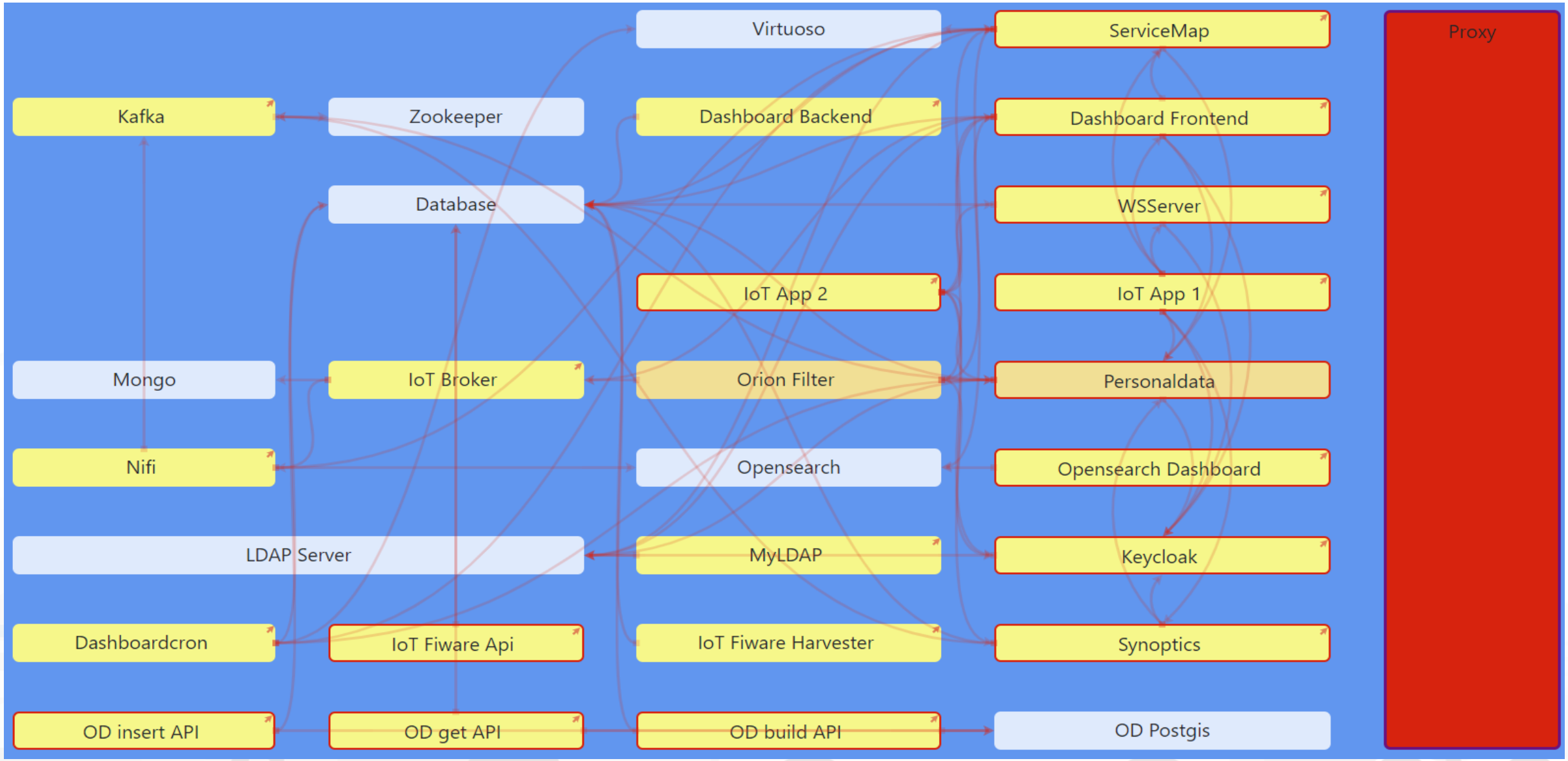


https://www.snap4city.org/docker-generator/selecting_model

Config Generator Tools

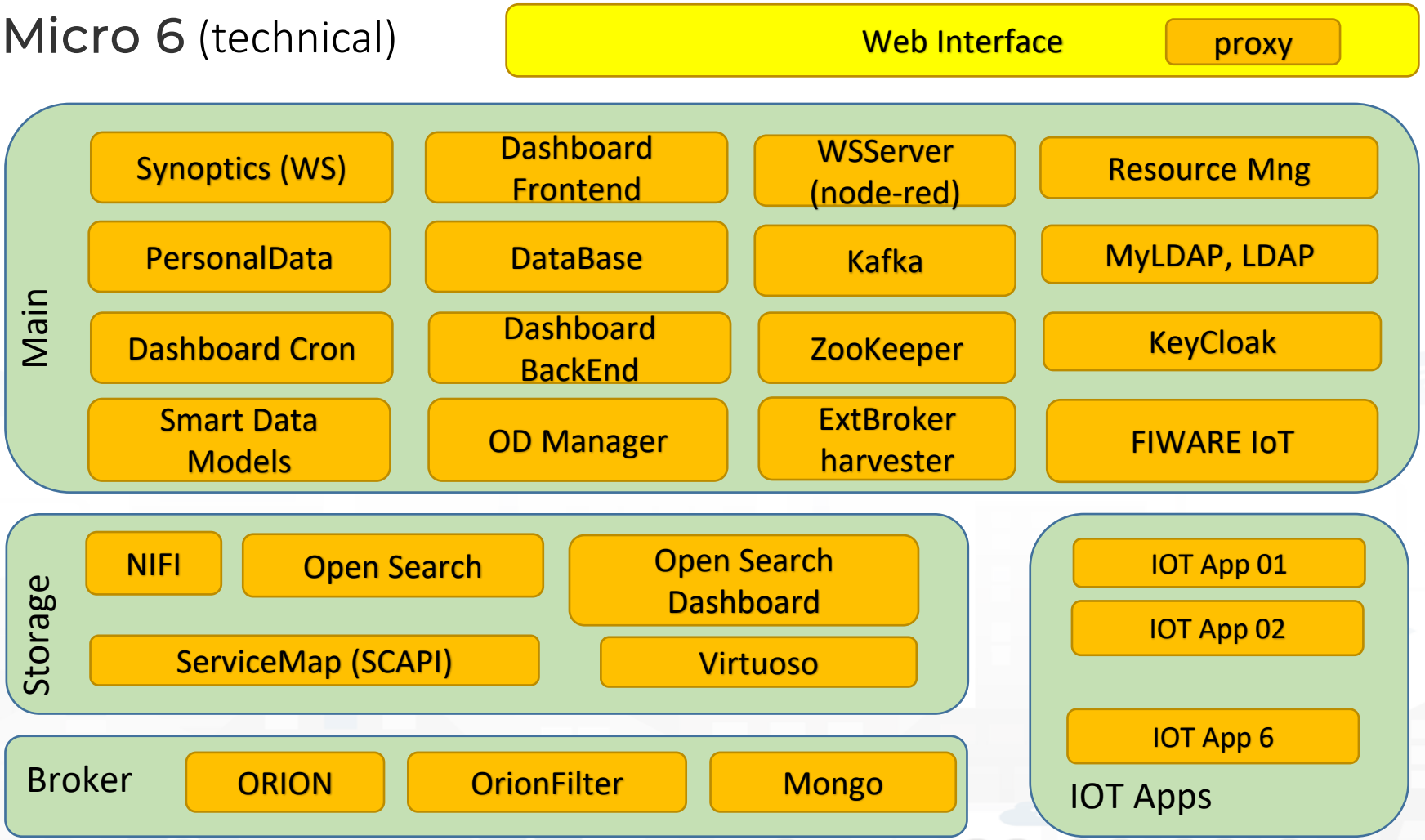


https://www.snap4city.org/docker-generator/selecting_model

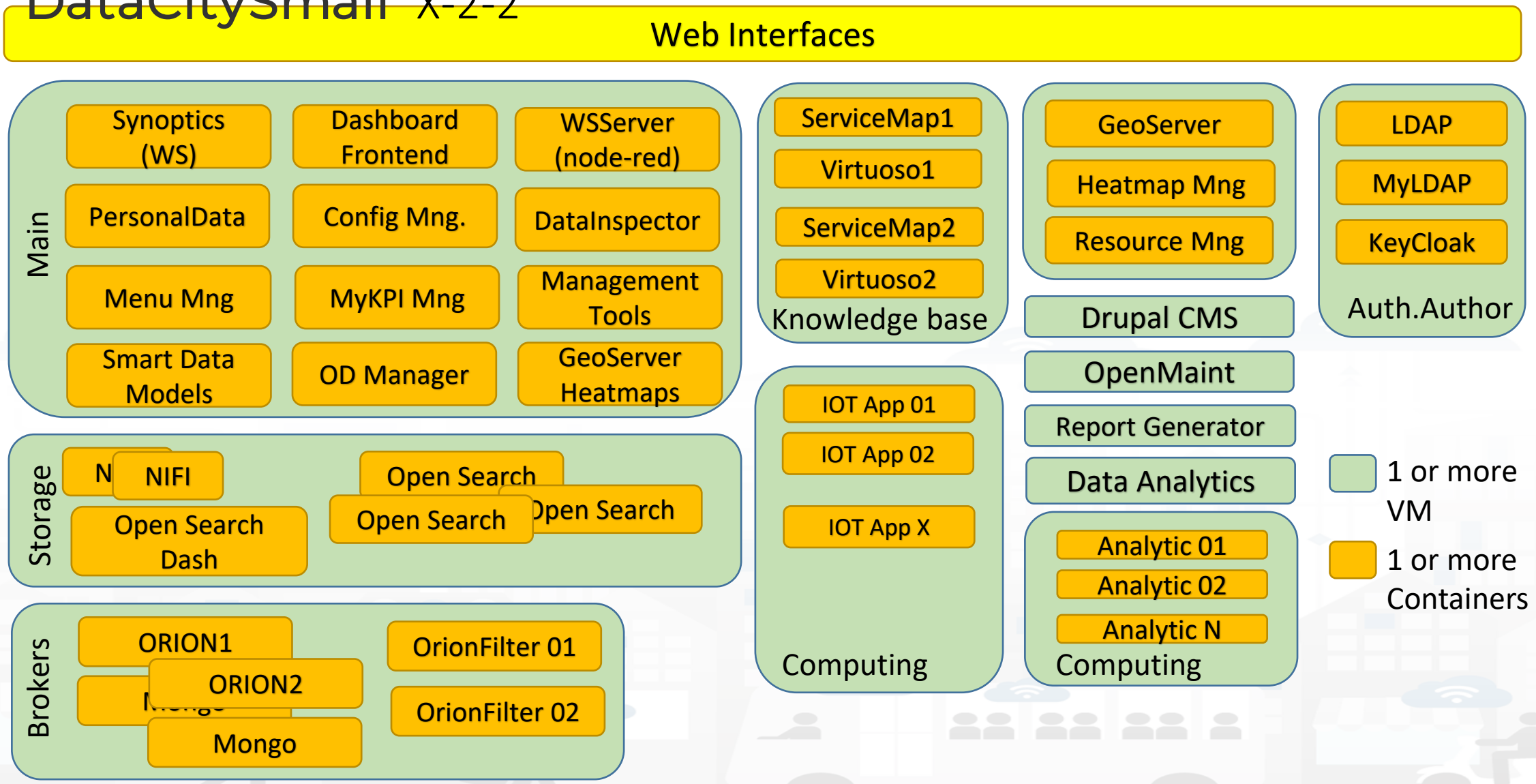

Virtuoso
ServiceMap
Proxy
Kafka
Zookeeper
Dashboard Backend
Dashboard Frontend
Database
WSServer
IoT App 2
IoT App 1
Mongo
IoT Broker
Orion Filter
Personaldata
Nifi
Opensearch
Opensearch Dashboard
LDAP Server
MyLDAP
Keycloak
Dashboardcron
IoT Fiware Api
IoT Fiware Harvester
Synoptics
OD insert API
OD get API
OD build API
OD Postgis

Micro 6 model

Micro 6 (technical)



DataCitySmall X-2-2



TOP

Esempi di Elaborati 2024/25

100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

Tipo A

- estensione di gestore dati per la gestione delle Traiettorie, percorsi di persone e mezzi,
- Gestione di MOUSE 3D per la navigazione su digital twin 3D di Firenze, via pagine web
- Digital Twin 3D della citta: uso di AI and 3D tiles in CESIUM format
- Digital Twin 3D della citta: inserimento di modelli 3D dinamici per la vegetazione
- Extending data ingestion process with NGSI LD compliant brokers, new version wrt the actual
  - uso del broker Orion NGSI LD per l'invio di dati verso NIFI Apache
- Editing di Scenario: aggiunta dell'editing di TPL, eventuale salvataggio del GTFS, o modifica in modo da poterlo salvare con altro tool.
  - sviluppo in Javascript per l'editing di scenari che rappresentano il trasporto pubblico, spostamento di fermate, modifica corse, recomputo tempi, rappresentazione e lavoro su grafica gia presente come MultiDataMap

A1) estensione di gestore dati per la gestione delle Traiettorie, percorsi di persone e mezzi

- Ogni traiettoria si può modellare come un singolo device che ha certe variabili, e le loro istanze sono una serie temporale
- La traiettoria riferisce ad un Mezzo, ad una persona, ad un device, etc., e viceversa
- La traiettoria deve potersi visualizzazione:
  - Valori storici, traiettoria in tempo reale
  - Visualizzare i cambio di stato, visualizzare i segmenti con le loro caratteristiche di velocità, accelerazione, etc.
  - Visualizzazione come time trend
  - Visualizzazione da DateTime a DateTime, o per day, o per week o per mese.
- Sviluppo in Snap4city multidata map, Deck, Javascript, HTMP, PhP.

A2) Aggiungere al 3D model della città, elementi di decoro urbano: alberi, semafori, auto, tramvia, etc.

- Ogni entità 3D ha delle informazioni di
  - Posizione (GPS ed altezza), 3D model da caricare (uno o piu' modelli),
  - dimensione, colore, stato: che possono incidere sulla visualizzazione del modello
    - potrebbe anche cambiare nel tempo: albero versione estiva, autunnale, invernale; semaforo; panchina; bike rack; etc.
  - data è scontata….
- Alcune potrebbero essere manipolabili: semafori, lampade, digital signage (pannelli a messaggio variabile), proiettori, etc.
  - Comunque sono variabili di una entità che possono o meno essere mappate su un colore della forma 3D oppure su ona forma diversa
- Sviluppo in PhP, Javascript, HTML, snap4city modeling

Tipo B

- sviluppo in Python di algoritmi per la generazione di heatmap: IDW, AKIMA o altri, via MLOps
  - uno o due modelli per ogni elaborato
- Conversione di modelli AI, deep learning per la predizione di serie temporali con stagionalità via MLOps, uno o due modelli per ogni elaborato
  - Modelli già presenti, oppure open
- soluzioni neuro simboliche per i modelli predittivi adattivi (semantici ed inferenziali) in connessione all'explainability dell'Artificial intelligence
  - come usare i risultati XAI di modelli predittivi per generate concetti simbolici che possono aiutare durante la iperparametrizzazione / training
- procedure di business intelligence, via CSBL, sviluppo in Python via MLOps ClearML, che vengono utilizzati tramite API, UNO sviluppo per ogni elaborato, per:
  - stima di statistiche descrittive, scatter plot, correlations, average, varianza, PCA, etc., sulla base di un set di serie temporali
  - Typical Time trends da una o piu' serie temporali.

Tipo C

- Processi di acquisizione dati, 2-3 sorgenti per ogni elaborato, in Proc.Logic, Node-RED on cloud
  - Da API REST: Dati di flusso di persone, meteo, etc.
  - Dati da sensori, dati da telecamere, etc.
- acquisizione di dati da sorgenti esterne e conversione, uno per ogni elaborato:
  - dati di tiled 3D, dati di traffico,
- revisione del progetto Data Table Loader/POI Loader per l'ingestion smart di dati anche con l'uso di CSBL e/o Python
  - https://www.snap4city.org/729
- sviluppo di un caso di studio: uso di modelli system thinking per il supporto alle decisioni, sviluppo di un processo node-red che calcola l'albero decisionale in una griglia della città e costruzione di una heatmap usando heatmap manager e API già presente.
  - tutto lo sviluppo in node-red con uso di dashboard per la visualizzazione
- Stima con processi di data ingestion di alcuni indicatori
  SUMI: https://www.snap4city.org/951 visualizzazione in dashboard standard, sviluppo Javascript
  - alcuni indicatori sono gia stati stimati altri possono essere aggiunti in questo elaborato
- scelta ed integrazione per sistema di lettura targhe di auto, che manda stream of da TV cam che già fa il riconoscimento:
  - using standard camera for car / scooter plate recognition,
  - Evento per esempio per aprire cancello, pay parking: managing white/black lists in real time