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

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

Big Data Architectures

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

Parte: 0 (2026-27)

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Agenda

- Laboratorio DISIT
- Tematiche del corso
- Struttura del corso
- Modalità dell'esame





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DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

Distributed Data Intelligence and Technologies Lab
Distributed Systems and Internet Technologies Lab

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DISIT Lab overview



http://www.disit.dinfo.unifi.it
https://www.disit.org

Visit the Smart City Platform of DISIT Lab: Snap4City https://www.snap4city.org solution which is 100% open source, support cloud and scalability for processing and IOT/IOE, respect user needs and privacy according GDPR and to the different user kinds, provide tools and community for co-creation; mixt data driven, stream and batch processing; it is fully based on microservices and using easily replaceable tools. Snap4City solution has been designed to be Click to access Snap4City tools main entry Click the image to access Snap4City scalable, flexible, safe and respectful of privacy, endowed of a powerful semantic reasoner based on Km4City multi-domain semantic model and tools (https://www.km4city.org). A special attention is provided to enable the development of applications in multiple domains and not only on mobility and transport, tourism, health, welfare, social, etc.

WORK with US: at DISIT lab UNIFI from January 2023

next call on 2023

The DISIT Lab, since 1994, is one of the most active ICT/AI labs of the University of Florence, metropolitan Tuscany area, and it is an official Regional Lab in Tuscany, Certified Experts of FIWARE, member of GAIA-X, EDIH Tuscan X, UNINFO ISO, CINI big data, CINI smart city, CNR, GBDAI, PhD AI national, etc.

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SNAP4CITY | KM4CITY

DISIT Lab at a glance, since 1994

University of Florence — Department of Information Engineering (DINFO).

ICT/AI lab with a long R&D track record.

- One the most relevant labs of UNIFI
- Official Regional Lab of Tuscany Region
- **Member of:**
  - International Advisory Boards: BBC, UNDP
  - international: GAIA-X, FIWARE, MDS
  - National ecosystems: EDIH Tuscany X.0, CINI, CNIT
  - National centers: CN MOST, FAIR
  - Regional centers: CBDAI (Tuscany), IFAB (Emilia Romagna)
  - PhD courses: national PhD-AI, PhD of DINFO
  - International Associations: AI*IA, IEEE, ACM



Publications: https://www.disit.org/5487

Around 20 researchers working on: Agentic AI, AI, big data in the domains of:

- smart cities, industry, retail, mobility & transport, environment, waste, energy, health, justice and quality of life.

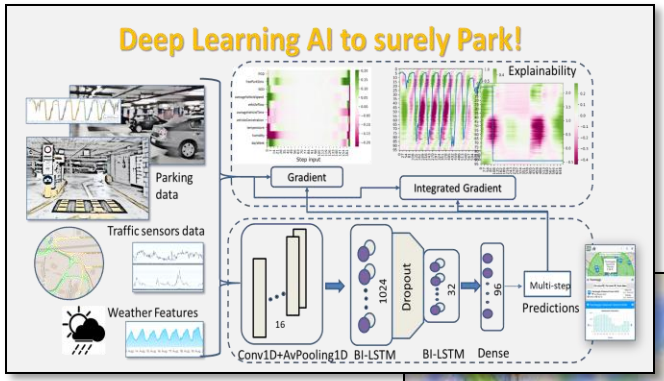
Dedicated Data center with several clusters: HPC CPU/GPU and MLOps

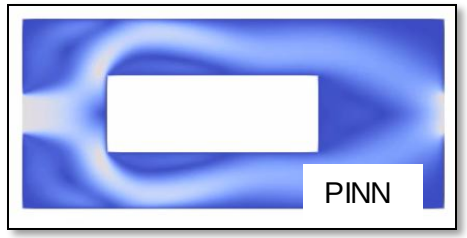
Research + platform engineering + real-world deployment

Core research areas

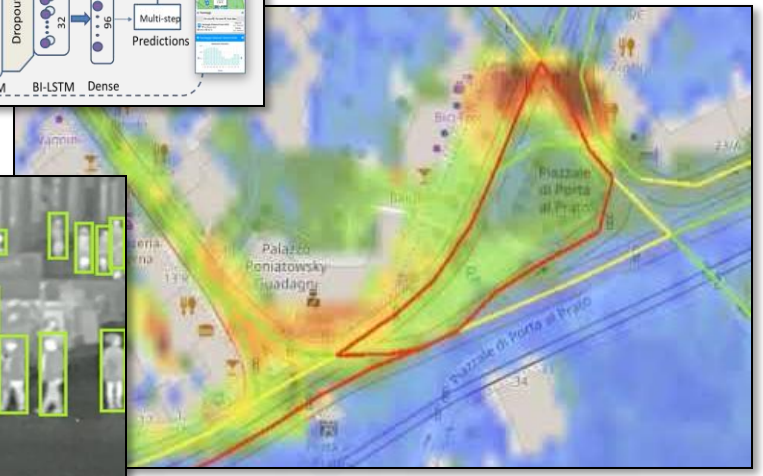
A research stack for trustworthy, explainable and operational AI, Digital Twins.

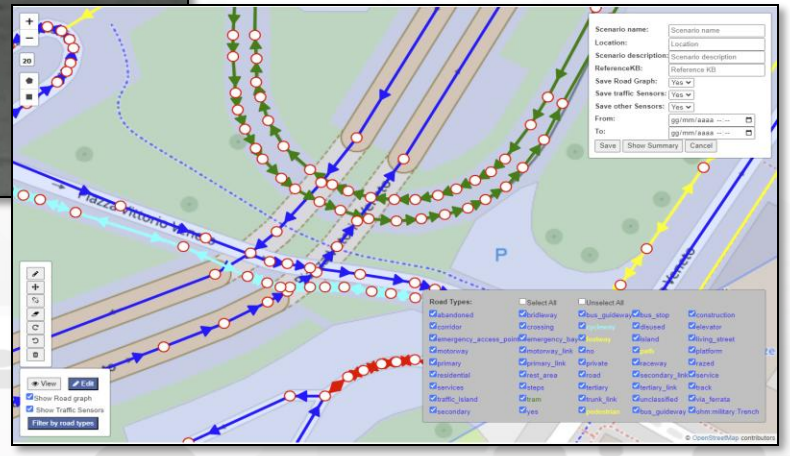
- **Artificial Intelligence and Machine Learning**: DL, GNN, RL, GCN, CNN, federated and scalable models.
- **Explainable and Neuro-Symbolic AI**: XAI, PINN, hybrid symbolic/data-driven reasoning.
- **Generative AI**, LLMs, Agentic AI, RAG systems for assistants, QA over Knowledge Graphs and RAG, dashboards and IoT/WoT applications.
- **Big Data, Data Spaces and distributed architectures**: cloud/edge and high-performance ingestion and data processing, active-active solutions, microservices, MCP.
- **Knowledge Engineering**: ontologies, RDF/KG, semantic indexing, reasoning, disambiguation and interoperability.







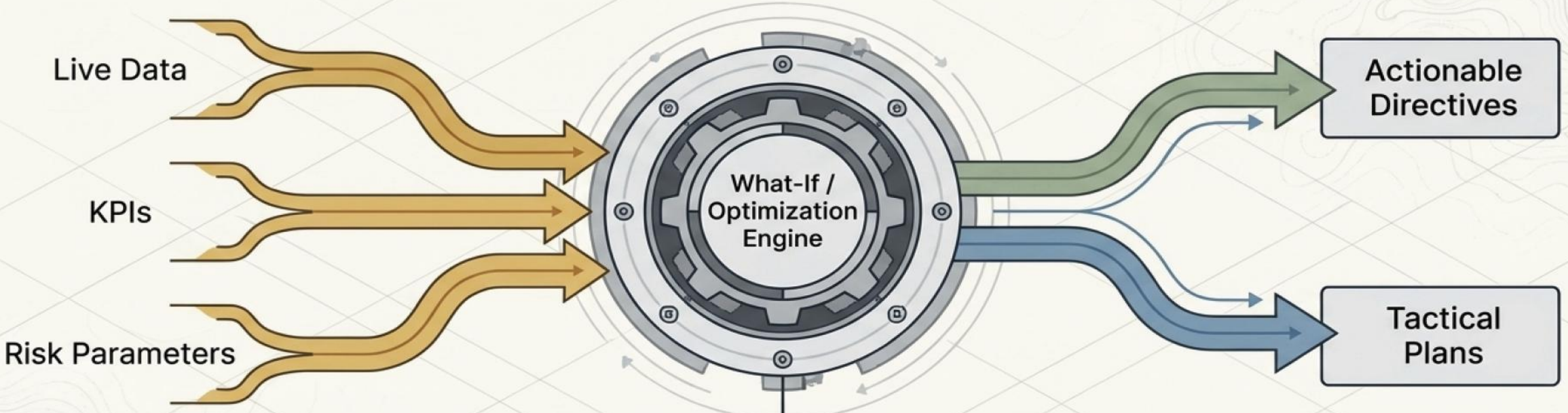




AI for prediction, explanation, optimization and scenario generation

© Snap4City, September 2026, DISIT lab

Decision Support Systems



What-If Analysis:
Grounded on robust predictive algorithms and simulations.

Scenario-Based Optimization:
Test traffic light plan optimizations digitally. Evaluate major traffic infrastructure changes. Assess tactical risks and generate prescriptions before spending public funds.

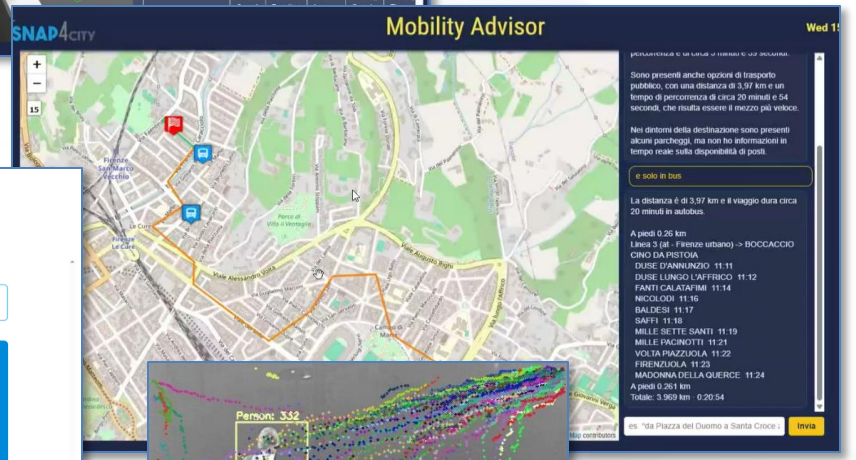
Applicative domains, operation & plan

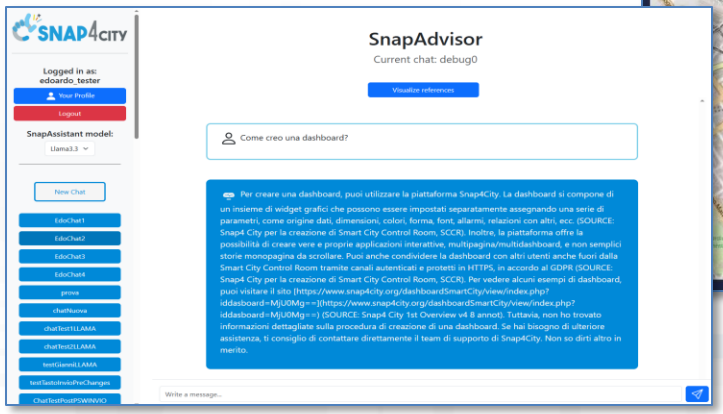
Pedictions, Early warning, Optimization

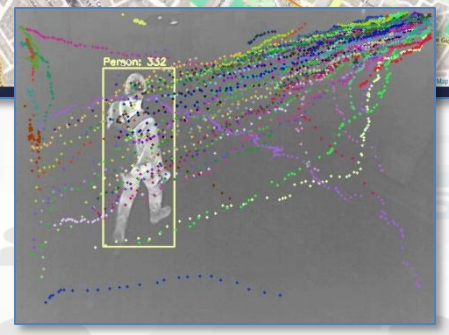
- **Smart Cities** Control & Applications
- **Mobility and Transport** Management
- **Industrial** applications
- **Tourism** services management
- **User Behaviour:** city, retail
- **AI Assisstants**: developers, legal, decision makers, commercials
- **Environment:** air quality, waste
- **Energy** Management











Infrastructures

- **Spin-off companies:**
  - Snap4 srl
  - DAI srl

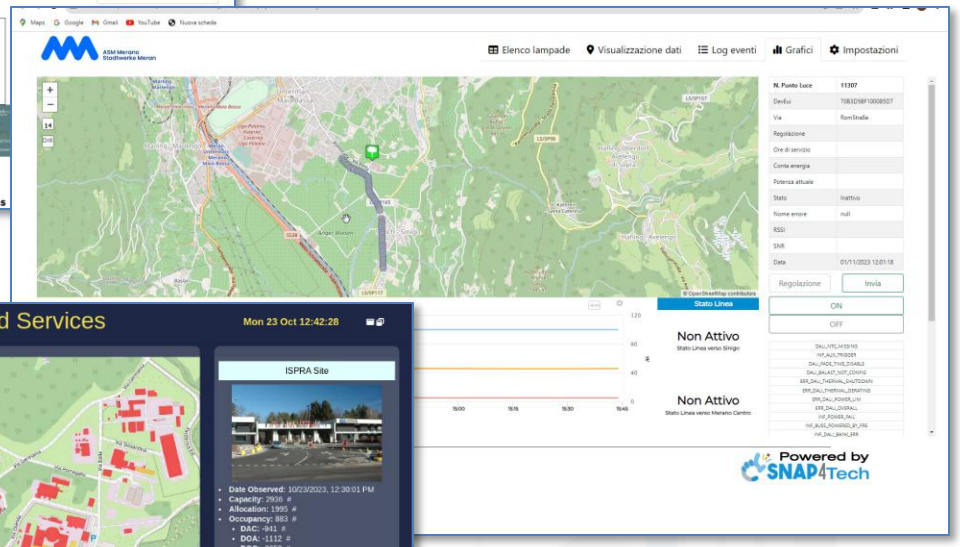
- **Platforms/Solutions:**
  - Snap4City.org
  - SnapAdvisor Agentic AI
  - Smart Cyprus + Mobile Apps
  - Merano's Smart Light
  - Cuneo's Smart Assets
  - Mobility4Future, CN MOST
  - Snap4ISPRA, EC ISPRA
  - Etc.

Snap4City.org

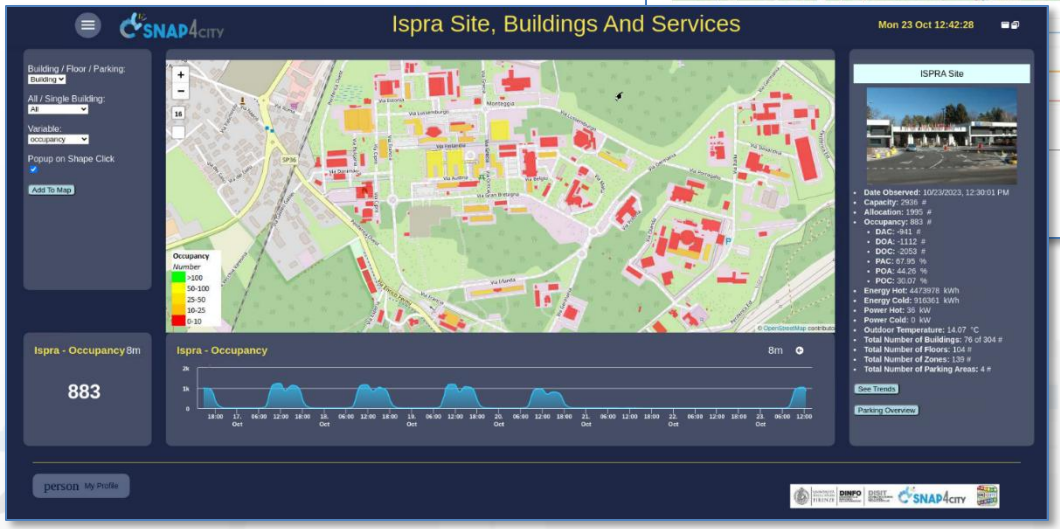




SmartCyprus



Merano



Snap4Ispra

Snap4City / Snap4Industry backbone

An open-source platform ecosystem for data-driven Smart City, Smart Region and Smart Industry solutions.

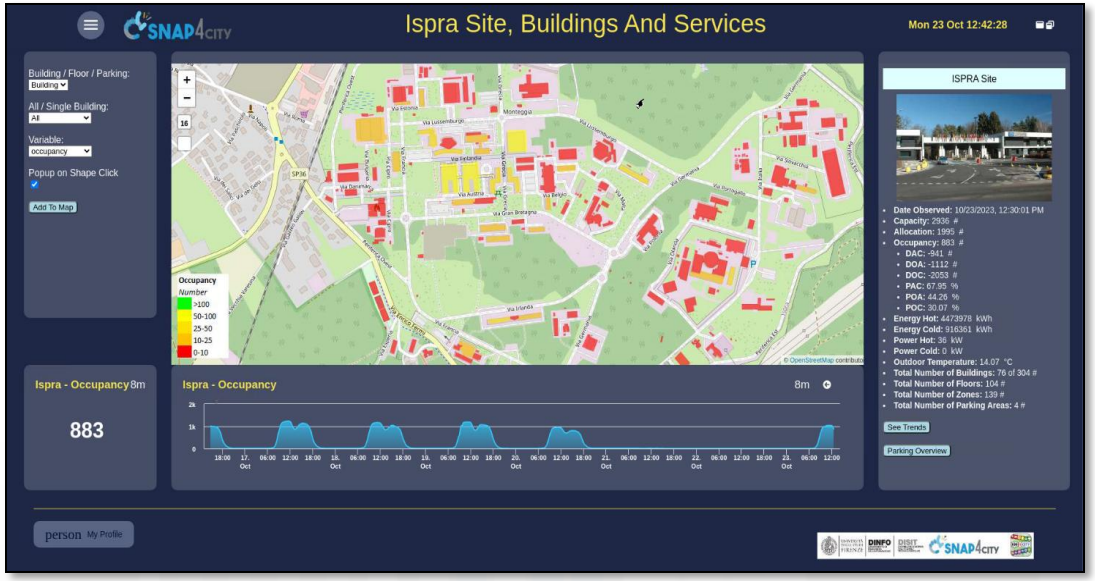
Microservices architecture for IoT/IoE, stream + batch processing and scalable cloud deployment.

Semantic layer based on Km4City for multi-domain reasoning and interoperability.

AI, Agentic AI, MLOps: development environment and AI solutions

Dashboards, control rooms, 2D/3D Digital Twins and no/low-code tools for operational users.

Designed for secure, privacy-respecting applications and GDPR-aware deployments, AI-Act, etc.

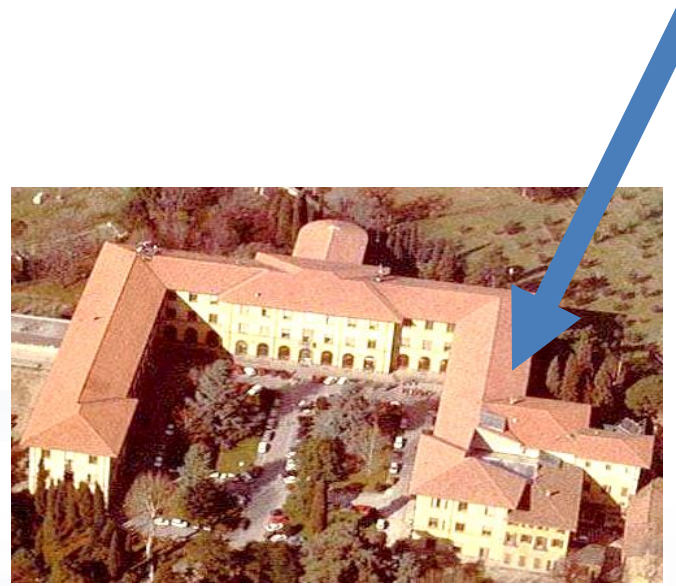


https://www.snap4city.org

Knowledge Model for the City

DISIT lab in numbers

- Researchers and contractors: 22
- Spin-offs: 2, that are: Snap4 srl, DAI srl
- Current Active Projects: 20
- Workstations: 30
- *Dedicated data center with*
  - >700 VMs, >30 hosts in clusters: DRS, HA, FT
    - >700 TByte storage in raid 50/60
    - >800 CPU cores, >8 TByte RAM
  - >140.000 GPU cores for a number of H100 NVL, RTX4090, etc.



Corsi di docenti DISIT lab

- **Magistrale in Informatica, Magistrale in Artificial Intelligence**
  - **Big Data Architectures** – Prof. Paolo Nesi (Big Data, Data Analytics, Architecture, Cloud, IoT)
  - **Knowledge Engineering** – Prof. Pierfrancesco Bellini (Knowledge Engineering, Natural Language Processing)
  - **NeuroSymbolic Artificial Intelligence at Scale** – Proff- Nesi and Fanfani
  - **CyberSecurity and Data Privacy** – Proff. Nesi and Bellini (Web security, privacy, GDPR, tracking)
  - **Natural Language Processing**, Prof. G. Pantaleo
- **Dottorati:**
  - PhD-AI, dottorato nazionale in Intelligenza Artificiale: P. Nesi
  - PhD del DINFO, dottorato in Ingegneria Informatica: P. Nesi, P. Bellini
- **Altri corsi:**
  - Master in Big Data-MABIDA: architetture, Big Data, Knowledge engineering, Natural Language Processing, cloud, etc.
  - Master IOT Industria 4.0 di Pisa – Prof. P. Nesi
  - Data Intelligence – Corso di Intelligence e Sicurezza Nazionale – Prof. Paolo Nesi
  - Altri master…..
- **Triennale**
  - Sistemi Distribuiti – Prof. Paolo Nesi
  - Sistemi Operativi – Prof. Pierfrancesco Bellini
  - Fondamenti di Informatica – Prof. Gianni Pantaleo, Stefano Bilotta

Infrastructure and support

- **Research group since 1994**
- **Cloud and data center** with >700 TByte storage in raid 50/60,
  - >800 CPU cores, >140.000 GPU cores, >8 Tbyte RAM
  - 2xH100 NVL, 4xRTX4090, 3xRTX3090, 2xGV100, 4rtx4500, etc.
  - Managing several infrastructures

- **DISIT lab/Snap4City.org :** development and testing **reference** for:
  - CN MOST
  - CN HPC, big data quantum computing
  - ISPRA JRC of EC
  - FIWARE Certificates and Experts
  - GAIA-X, EOSC, Node-RED library, Mobility Data Space, etc.
  - Nodo CINI per: Big data, Smart City, Security
  - Smart Cyrus, Merano, Cuneo, etc.

SNAP4CITY roadmap

Smart Ambulance (2021-22)

Enterprise (2021-22) Industry 4.0

Almafluida Industry 4.0 (2021-22)

Contract, 2022-23

CN MOST, 2022-26

ELLIE IA 2025-2027

UrbanDT4TF

2020

- Smart Tourism
- 6 Pilots
- Data Analytics
- Extended platform

Contract

- Smart Mobility
- PISA, PUMS
- Living lab

Km4City 1.6.7

2021

Contract

Contract

PC4City (2020-21) Monitoring Terrain

Winner of Open Data Challenge of

- Smart Light
- Sweden

Asymmetrica Smart City, 2022-23

AMPERE (2021-22) Industry 4.0

SYN-RG-AI SmartCity

Industry 4.0

SmartCity, 2021-23

AXIS collab SmartCity

2022

Italferr, Smart City

2023

Contract, 2022-23

2022-2023

Contract, 15min

Security and Risk

Smartea

TOURISMO

EI THE, 2022-26

G. Agile, 2021-23

2023-26

Merano, smart light

OceanRace, Genova, AWS

Cuneo, smart city

2024

Km4City 1.6.8

Contract, 2024-25

CAI4DSA

OPTIFaaS

SASUAM

Rhodes, smart city

eShare

UNIFI TUSS

AMMIRARE

- **Smart Cyprus:** Parking, participation, Light, Waste, etc.
- **ISPRA JRC contract**, EC: DSS, SOC, control room, energy, https://www.snap4city.org/970
- **Merano Smart Light**, contract https://www.snap4city.org/1023
- **Cuneo Asset management**, contract https://www.snap4city.org/975
- **TOURISMO**, Interreg, EC: Tourism, NLP, DSS, https://www.snap4city.org/1001
- **ELLIE**, Horizon Europe, EC: AI, VR, https://www.snap4city.org/1056
- **AMMIRARE**, Interreg, EC: AI, environment, Big Data, https://www.snap4city.org/1002
- **Reg4IA**, LLM, DL AI for regional public administration, A project of presidency of national council
- **Energia**, RT, contract: Federated Learning, AI, PINN, DSS, on manufacturing
- **SADI-MIAC**, RT, partner: AI predictions, Tourism, Retail, Computer Vision, https://www.snap4city.org/1055
- **CN MOST**, PNRR: sustainable mobility, AI, platform, https://www.snap4city.org/1050
- **MUSEOAct**, Deep Learning AI for condition deformation predictions wrt environmental aspects
- **Reverberi contract**, Smart Parking monitoring
- **LIBROCO**, AI for predicting events effects on commerce, LLM
- **RFI contract**: mobility, AI, DSS
- **++ other contracts covered by NDA**

Closed in 2025-early 2026

- **BullVIT**, RT, conv: Agentic AI, NLP, LLM on commercial phases
- **UrbanDT4TF**, CN HPC: Digital Twin mobility, https://www.snap4city.org/1057
- **DI-DTPlatform**, CN HPC: Digital Twin, mobility, environment, https://www.snap4city.org/1097
- **Sasuam**, CN MOST, PNRR: AI, mobility, https://www.snap4city.org/999
- **OPTIFaaS**, CN MOST, PNRR: AI, mobility, DSS, https://www.snap4city.org/1008
- **LeverageOPTIFaaS**, CN MOST: PNRR, mobility, https://www.snap4city.org/1064
- **CAI4DSA**, FAIR PE1, PNRR: AI, Neuro-Symbolic, PINN, NG-DSS, https://www.snap4city.org/1016
- **SMART3R,** PRIN UNICagliari: mobility, DSS, https://www.snap4city.org/1087
- **Tuscany X.0, EDIH,** TestBeforeInvest, Training on AI, Big Data, Security, HPC: https://www.tuscanyx.eu/
- **The IE**, PNRR: AI, NLP, LLM, Legal Aspects, SnapAdivisor, RAG LLM
- **Salerno Port**: AI for container ID recognition and tracking
- **Talent Hub**, ECRF, conv: NLP, match demand vs offer

booklets

- Smart City



https://www.snap4city.org/download/video/DPL_SNAP4CITY.pdf

- Industry



https://www.snap4city.org/download/video/DPL_SNAP4INDUSTRY.pdf

- Artificial Intelligence



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

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SMARTCITY
EXPO WORLD CONGRESS







OPTIFaaS

AI-Powered Digital Twin Platform for Mobility & Transport Operation and Plan

Urban Challenges & OPTIFaaS Objectives

From data to action : Tailored Mobility Services

The Core

Snap4City / OPTIFaaS delivers mobility solutions for operational management and strategic-tactical planning through an integrated Digital Twin and various AI models, enabling what-if analysis, simulation, and optimization

Objectives



Decongestion



Safety



Accessibility



Cost Reduction



Decarbonization

OPTIFaaS → Scalable, flexible, customized mobility solutions

Supports various urban contexts from small communities to large metropolises

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

Spoke 8
MaaS & Servizi Innovativi per la Mobilità
Centro Nazionale per la Mobilità Sostenibile

OPTIFaaS - Operation and Plan, Transport Infrastructure and Facilities Support as a Service

Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA
Ministero dell'Università e della Ricerca
Finanziato dall'Unione europea
NextGenerationEU

CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

OPTIFaas

Ecosistema a supporto di una rapida ed efficace condivisione di soluzioni ed opportunità tra **ricercatori** ed **aziende** appartenenti al MOST e **Pubbliche Amministrazioni Locali** ed **Operatori di Trasporto**.

Meccanismo del tipo marketplace:

- **Ricercatori ed Aziende del MO**ST hanno un ambiente in cui proporre e sperimentare proposte e soluzioni;
- **PAL ed OdT** utilizzano sempre soluzioni allo stato dell'arte per la risoluzione di problematiche ed il perseguimento della loro mission.

Il tutto è configurato con modalità ***as a service*** allo scopo di **minimizzare investimenti** in infrastrutture e personale da parte di PAL e OdT



L’ottimizzazione generativa permette di:

- ✓ **Decongestionare le strade:** ottimizzando i tempi dei semafori, i flussi di traffico e le vie di transito per ridurre i punti di congestione critica.
- ✓ **Migliorare l’accessibilità:** Promuovendo la connettività tra le aree urbane, migliorando l'accessibilità per pedoni, ciclisti e veicoli attraverso un miglioramento della pianificazione urbana.
- ✓ **Aumentare la sicurezza:** Implementando strategie per migliorare la sicurezza stradale, ad esempio attraverso la riduzione dei punti di conflitto e l'ottimizzazione dei flussi di traffico.



LUTECH BRAIN MOBILITY 4 FUTURE

Operation

OPTIFaaS

indietro log-out

- Home
- Traffic Monitoring
- Smart Parking
- 15 minuti index
- Urban Security



Road Monitoring

Media congestioni	Nr. congestioni	Picco congestioni	Riduzione Co2 ZTL	Emissioni medie CO2	Emissioni totali CO2
28.4 %	17 -	18:27 -	-5.2 %	282 ppm	846 ppm

Traffico in ingresso



Tot. veicoli in ingresso: 12105 Veicoli

Velocità media: 27 km/h

Traffico in uscita



Tot. veicoli in uscita: 11703 Veicoli

Veicoli totali: 7825 -

Pannello Rischi Meteo

MINIMO | BASSO | MEDIO | ALTO

Rischio Idraulico	MINIMO	Rischio Idrogeologico	MINIMO
Rischio Temporali	MINIMO	Rischio Neve	MINIMO
Rischio Ghiaccio	MINIMO	Rischio Vento	MINIMO

Viabilità

INCIDENTI	3
Chiusura Traffico	2
Chiusura Lavori	0
Limitazioni Traffico	4
Limitazioni Lavori	0
SEGNALAZIONI	7

Trasporto Pubblico

Tempo medio di attesa: 5.9 sec

Ritardo autobus: 0 %

Attesa Media Fermate

Linea 50	12 sec
Linea 11	10 sec
Linea 33	6 sec
Linea 02/	5 sec
Linea E	5 sec
Linea 19	4 sec

Sensori

15 Semafori	3
22 Videocamere	0
4 Sensori	1

Powered by SNAP4Tech

Collaborative Explainable neuro-symbolic AI for Decision Support Assistant

- **New Algorithms or Models**: Development of novel AI algorithms or models that can enhance decision-making processes.
- **NGDSS Theories**: Contribution to the theoretical understanding of how AI can be effectively integrated into decision support systems.
- **Early Prototype** of the NGDSS, providing a proof of concept for how AI can enhance decision-making in a number of target domains

Interreg
Euro-MED

Co-funded by
the European Union

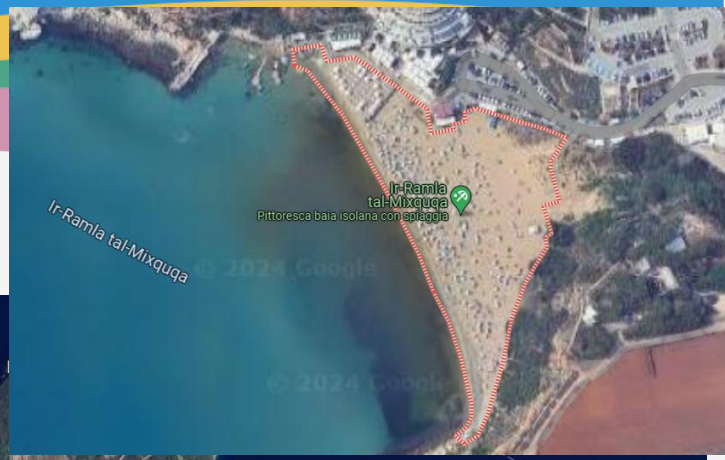
TOURISMO EURO MED

TOURism Innovative and Sustainable Management of flOws

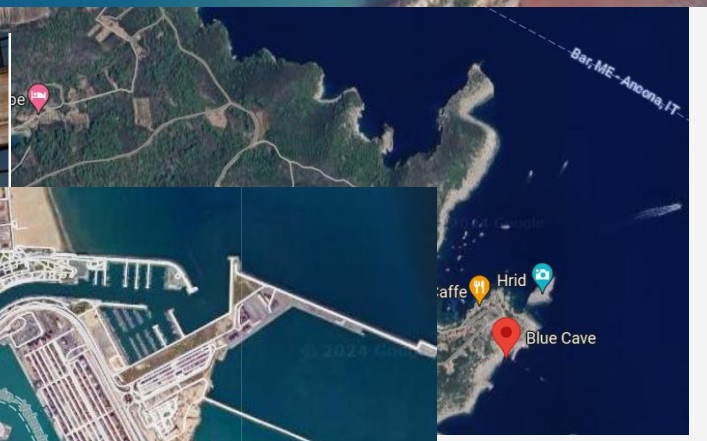
SNAP4CITY

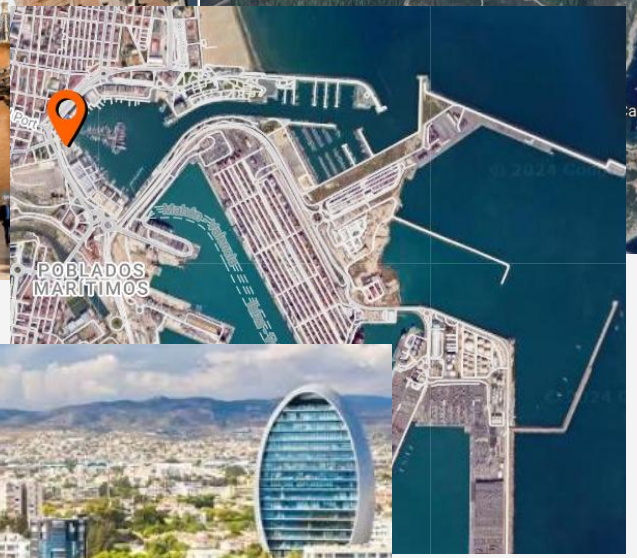
- Pilots of Snap4City on:
  - Greece - READ S.A.: Rodi
  - Italy – FRI, UNIFI: Firenze
  - Spain – FV, FSMLR: Valencia
  - Cyprus – ANELEM: Limassol
  - Bulgaria – VEDA: Varna
  - Croatia – RERA SD: Splitsko-dalmatinska županija
  - Malta – MRDDF: La Valletta



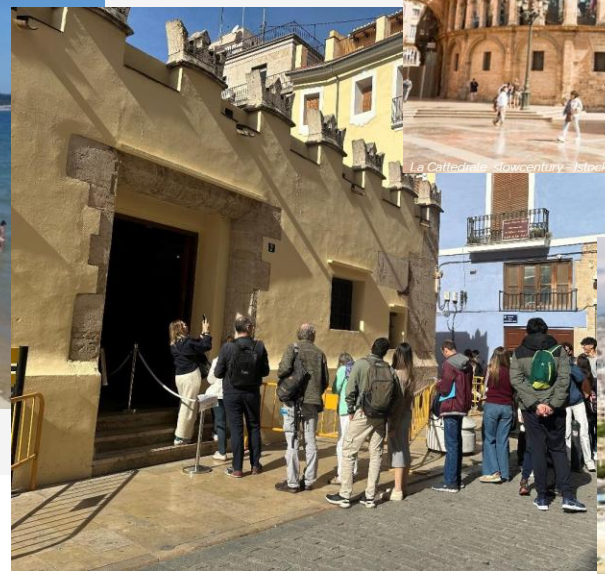








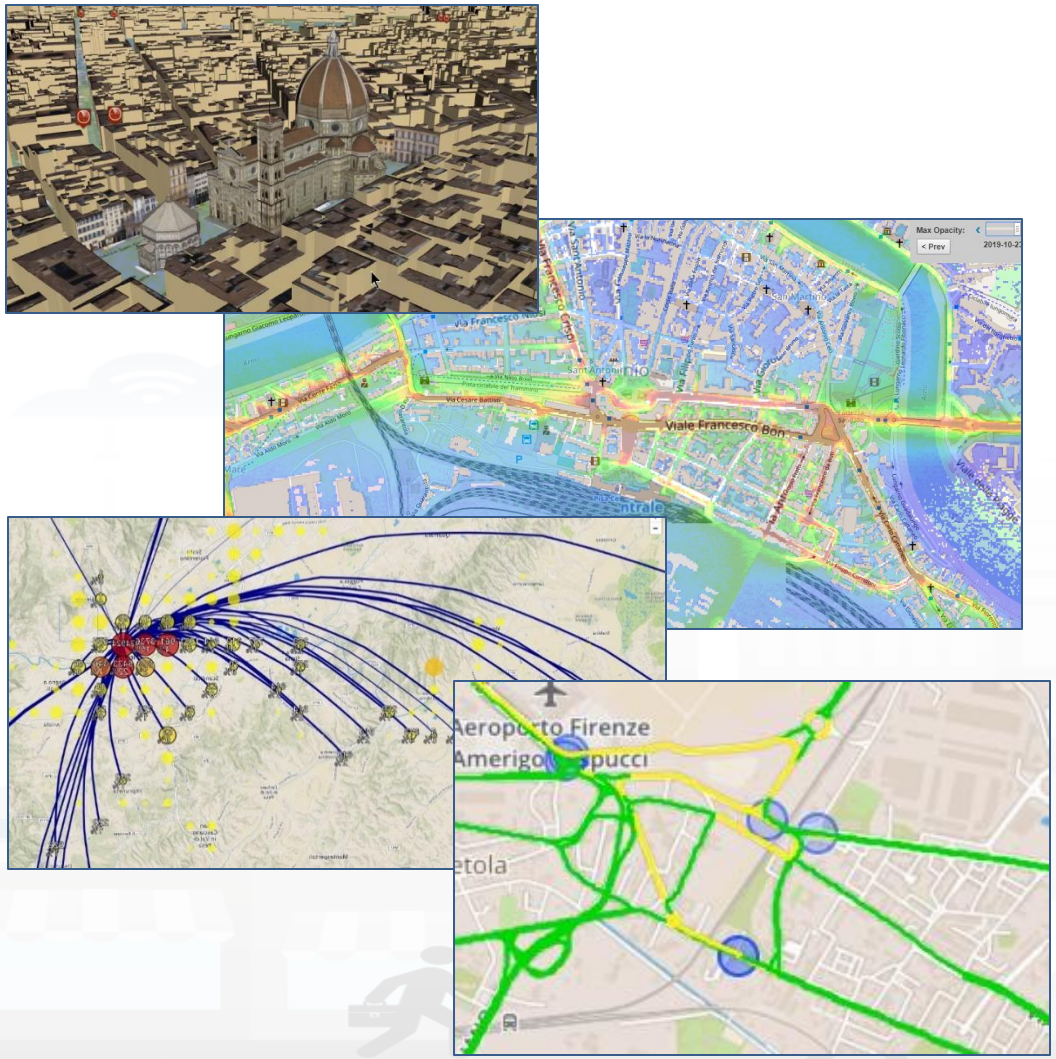






Interreg Euro-MED
Co-funded by the European Union

Smart City Digital Twin

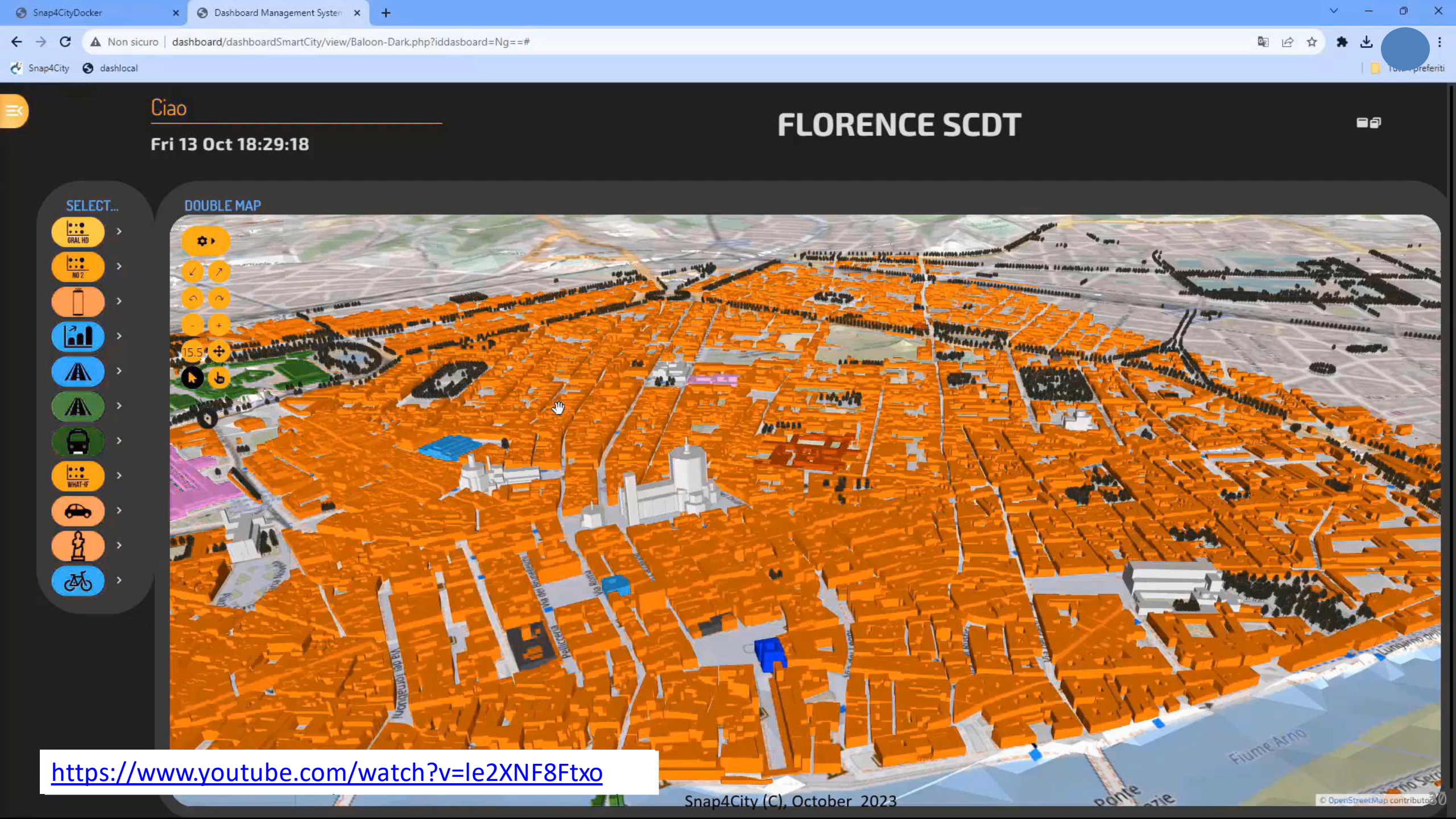


City Digital Model with…

- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Interactive Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis – Simulation, prediction, 2D/3D
- Micro, Meso e macro scales
- Operation, planning tactic and strategic / optimization
- Collaborative and shared representation
- Sustainable, shared, open source 100%

Complex and heterogeneous information, interoperability

- GIS, ITS, AVM, IoT, BIM, CKAN, etc.
- Satellite services
- MaaS, last-mile delivery HUBs
- etc.

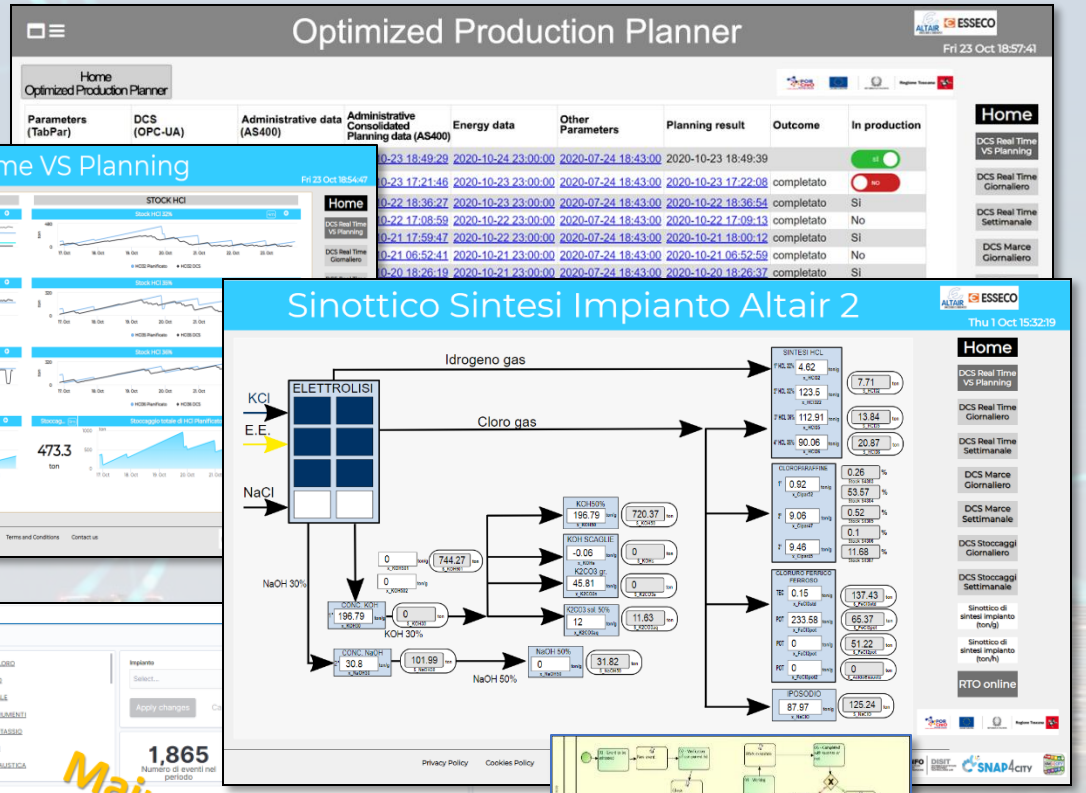

Snap4CityDocker
Dashboard Management Syster
Non sicuro
dashboard/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=Ng==#
Snap4City
dashlocal
Ciao
Fri 13 Oct 18:29:18
FLORENCE SCDT
SELECT...
DOUBLE MAP
GRAL HD
NO 2
WHAT-IF
Fiume Arno
Snap4City (C), October 2023
https://www.youtube.com/watch?v=le2XNF8Ftxo

Snap4Altair Decision Support supervision and control, Industry 4.0

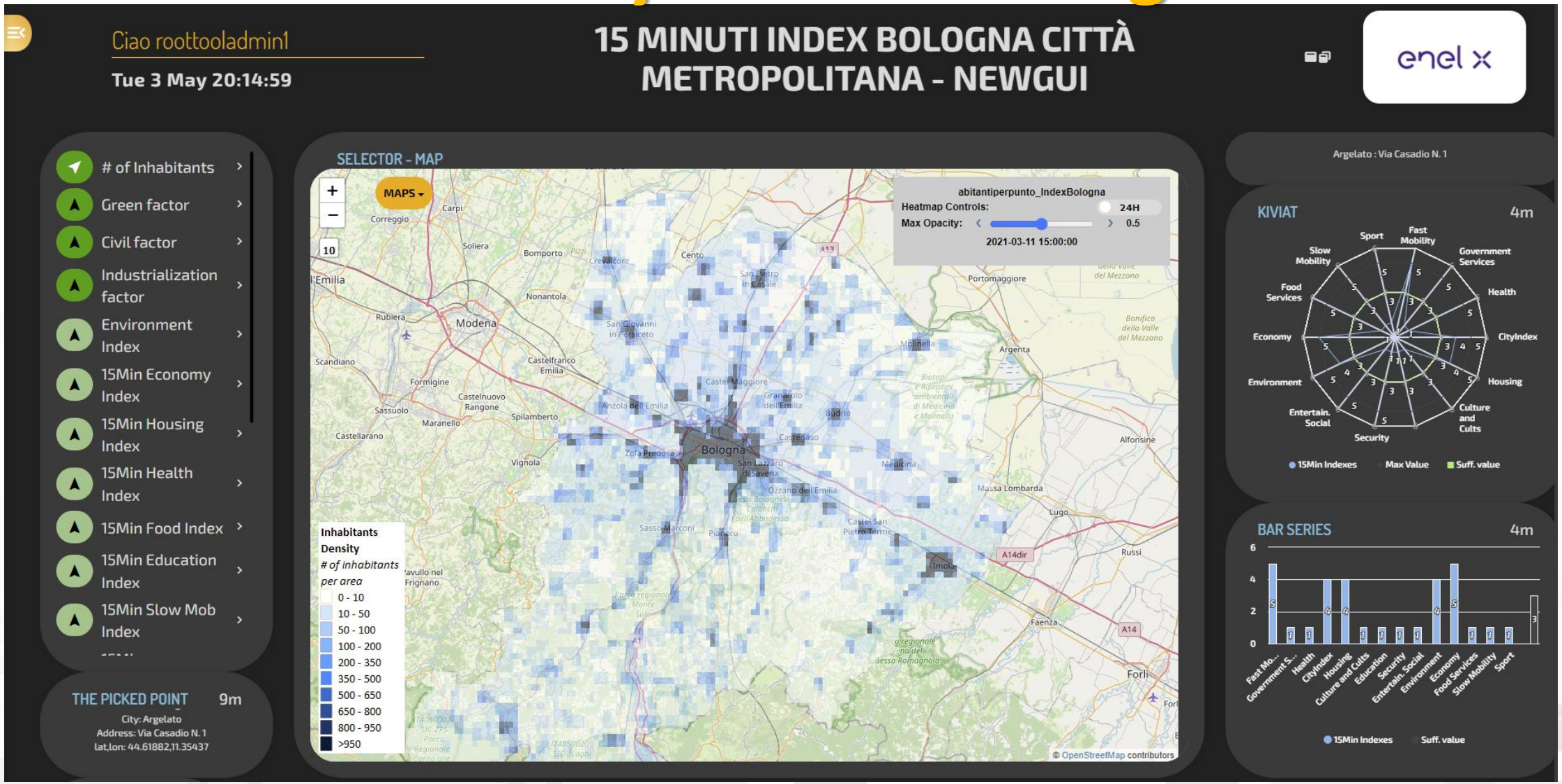
reference

- **Multiple Domain Data**
  - Distributed Control System: energy, flows, storage, chemical data, settings, ..
  - Cost of energy, Orders,
  - Production Parameters
  - Maintenance data
- **Multiple Levels & Decision Makers**
  - Optimized planning on chemical model
  - Business Intelligence on Maintenance data
- **Historical and Real Time data**
  - Billions of Data
- **Services Exploited on:**
  - Multiple Levels, Mobile Apps, API
- **Since 2020**





15MinCityIndex on Bologna



https://www.snap4city.org/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=MzQxMg==

Regione Toscana

Fondazione per la ricerca e l'innovazione

Interreg Mediterranean HERIT-DATA



Sustainable and responsible Tourism Management

Key aspect: **Carrying Capacity**

consider **European Tourism Indicators ETIS**

Respectful of the **ICZM recommendations**

Cultural heritage

Special interest on **UNESCO World Heritage Sites**

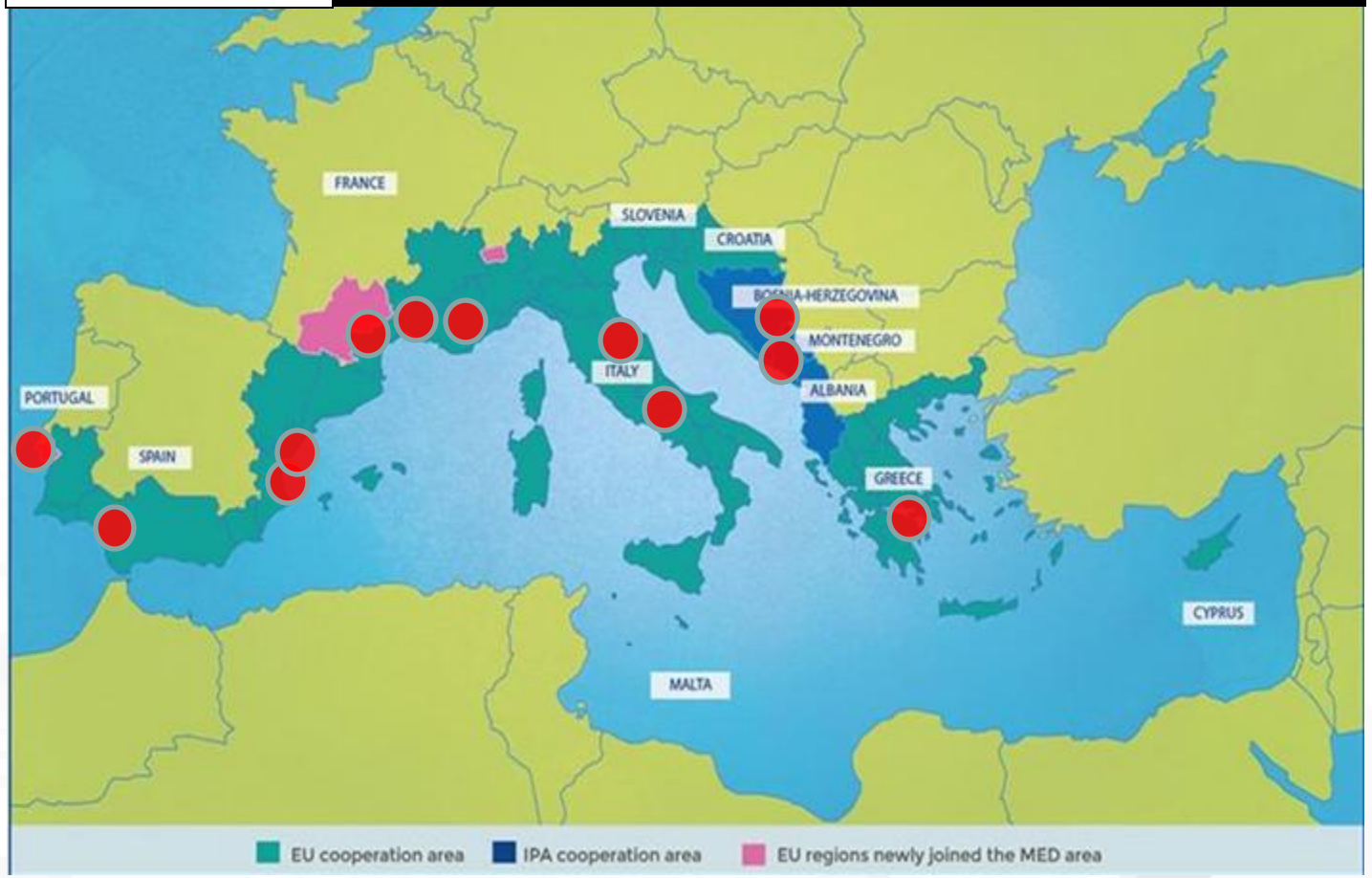
Evaluation of impact

Big & Open data

At service of Planners, visitors, local stakeholders and dwellers

Interreg Mediterranean HERIT-DATA

Sustainable Heritage Management towards Mass Tourism Impact thanks to a holistic use of **Big and Open Data**

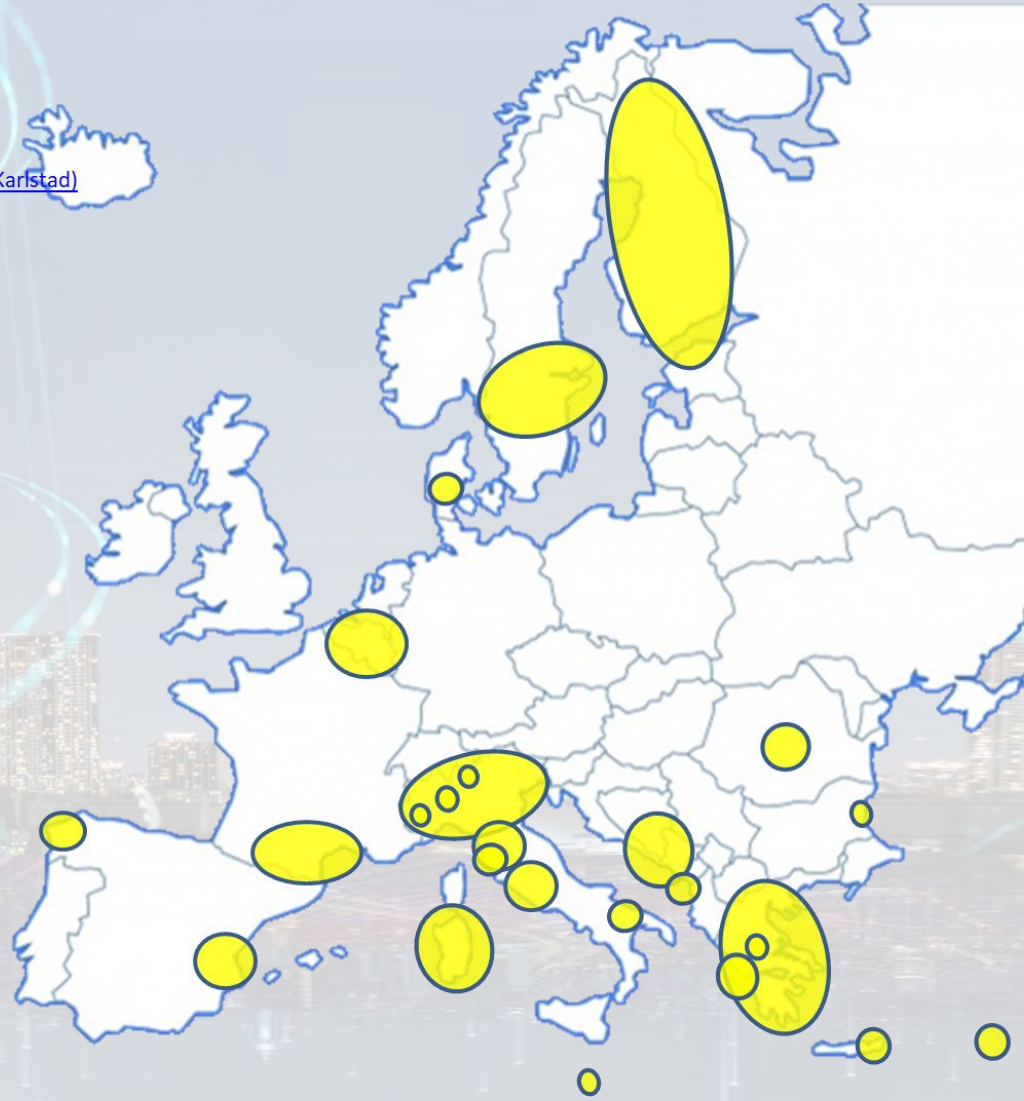


https://www.Snap4City.org

- 11 running installations in Europe
  - Snap4city.org, Greece, Merano, Cuneo, …
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, M4F, Romania, ….
- 20 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Widest MULTI-tenant deploy has**
  - 26 Organizations / tenant
  - > 8850 users on
  - > 1800 Dashboards
  - > 17 mobile Apps
  - **> 2.2 Million of structured data per day**
  - > 580 IoT Applications/node-RED
  - > 850 web pages with training
  - > 85 videos, training videos

Main Organizations/areas

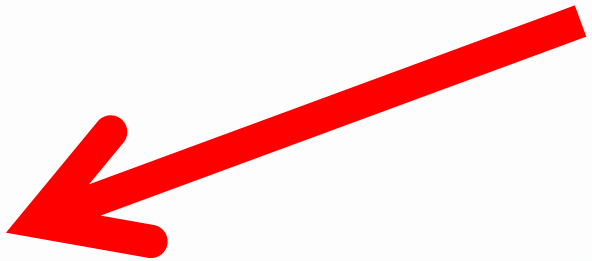
- Antwerp area (Be)
- Bari (I)
- Bisevo, Croatia
- Bologna (I)
- Brasov (Ro), by ICEBERG
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- Cuneo (I)
- DISIT demo (multiple)
- Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Greece (Gr)
- Helsinki area (Fin)
- Limassol (Cy)
- Livorno area (I)
- Lonato del Garda (I)
- Malta (Malta)
- Merano (I)
- Modena (I)
- Mostar, Bosnia-Herzegovina
- Oslo & Padova (Impetus)
- Pisa area (I)
- Pistoia (I)
- Pont du Gard, Occitanie (Fr)
- Prato (I)
- Rhodes (Gr)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- Siena (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Varna (Bulgaria)
- Venezia area (I)
- WestGreece area (Gr)



- **+ Israel, Colombia, Brasile, Australia, India, China, etc.**

Agenda

- Laboratorio DISIT
- Tematiche del corso
- Struttura del corso
- Modalità dell'esame



Open day

Pensa in grande, inizia da qui

A cosa serve un Digital Twin?

- **Tecnologie rivoluzionano la gestione urbana.**
- **Gestione Operativa**
  - **Osserva** e verifica lo stato dei servizi
  - **Anticipa** i problemi prima che si verifichino
  - **Ragiona**: simulazione e identifica soluzioni a breve termine
  - **Propone** soluzioni in tempo reale, l'operatore decide
- **Pianificazione tattico/strategica:**
  - progettare città più intelligenti e sostenibili.
  - Soluzioni tradizionali sono le «what-if»: *cosa accadrebbe se ….?*
  - **simulare e ottimizzare** per l'efficienza urbana.
    - sistemi a grande scala (Big), molte variabili e miliardi di milioni di configurazioni diverse!
- **propone soluzioni al decisore**
  - → Decision Support Systems

Global



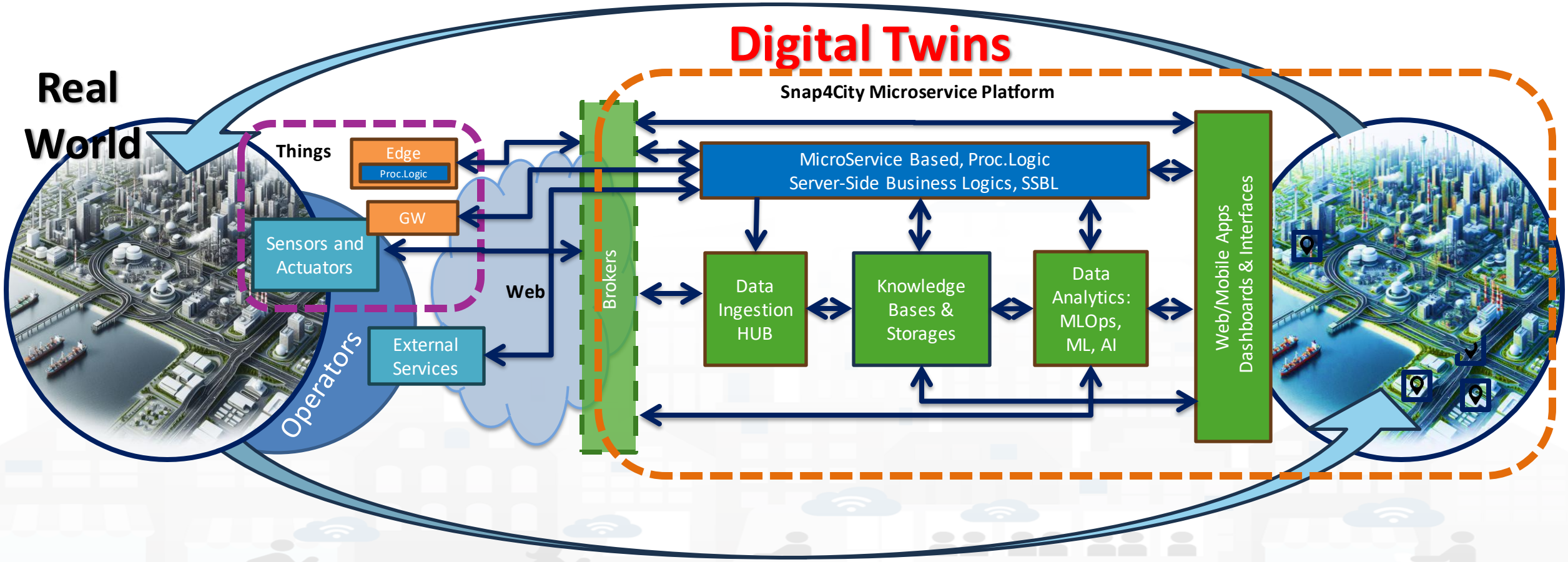


Local

UNIVERSITÀ DEGLI STUDI FIRENZE

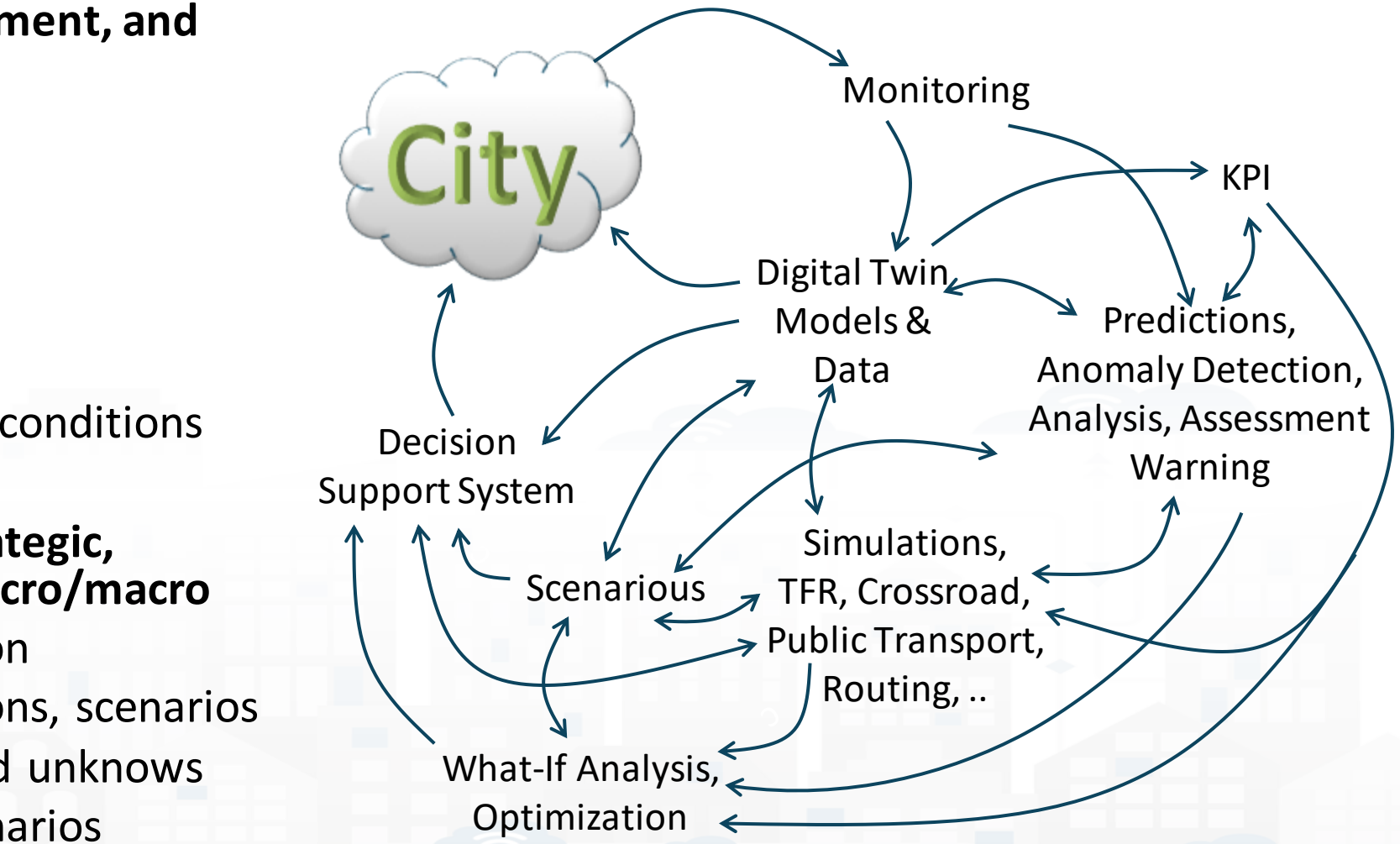
Da un secolo, oltre.

Digital Twin Development Platform



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
  - Fast What-if analysis
- **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
  - Collaboration with stakeholders





City

Monitoring

KPI

Digital Twin
Models &
Data

Predictions,
Anomaly Detection,
Analysis, Assessment
Warning

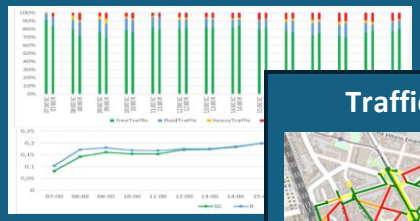
Decision
Support System

Scenarious

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

What-If Analysis,
Optimization

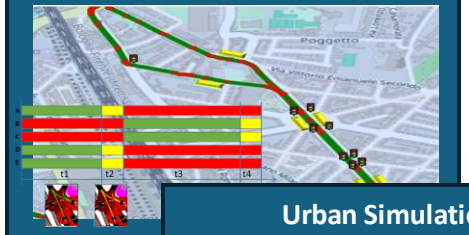
KPI, Predictions, ...



Traffic Reconstruction



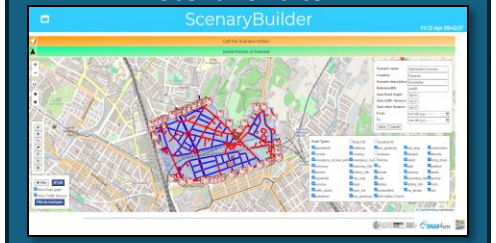
Traffic Light Plan optimization



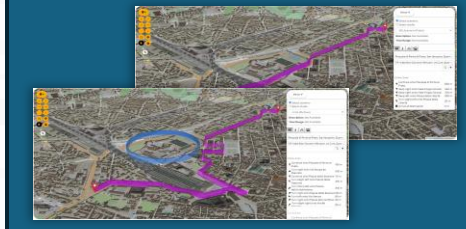
Urban Simulation



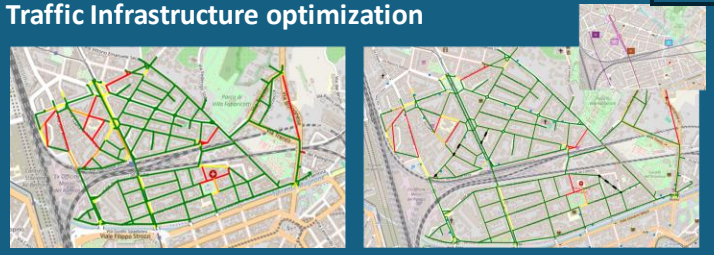
Scenario Editor



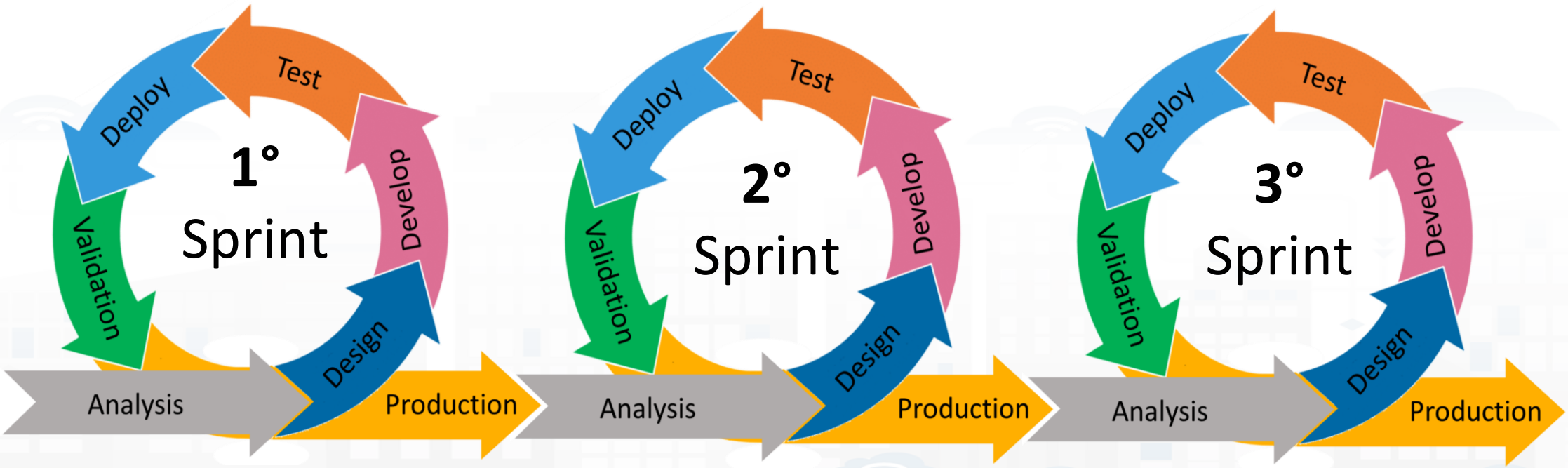
Routing / Dynamic Routing



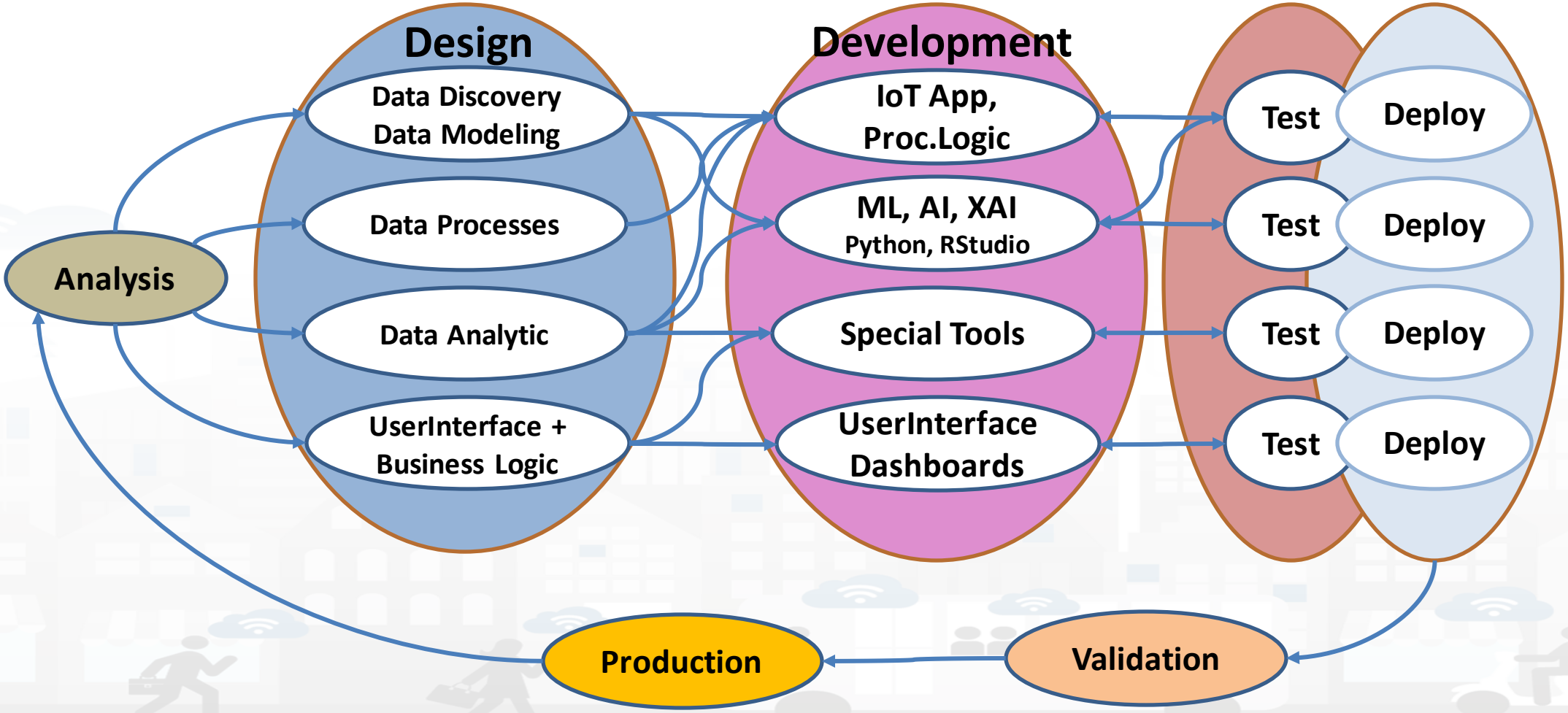
Traffic Infrastructure optimization



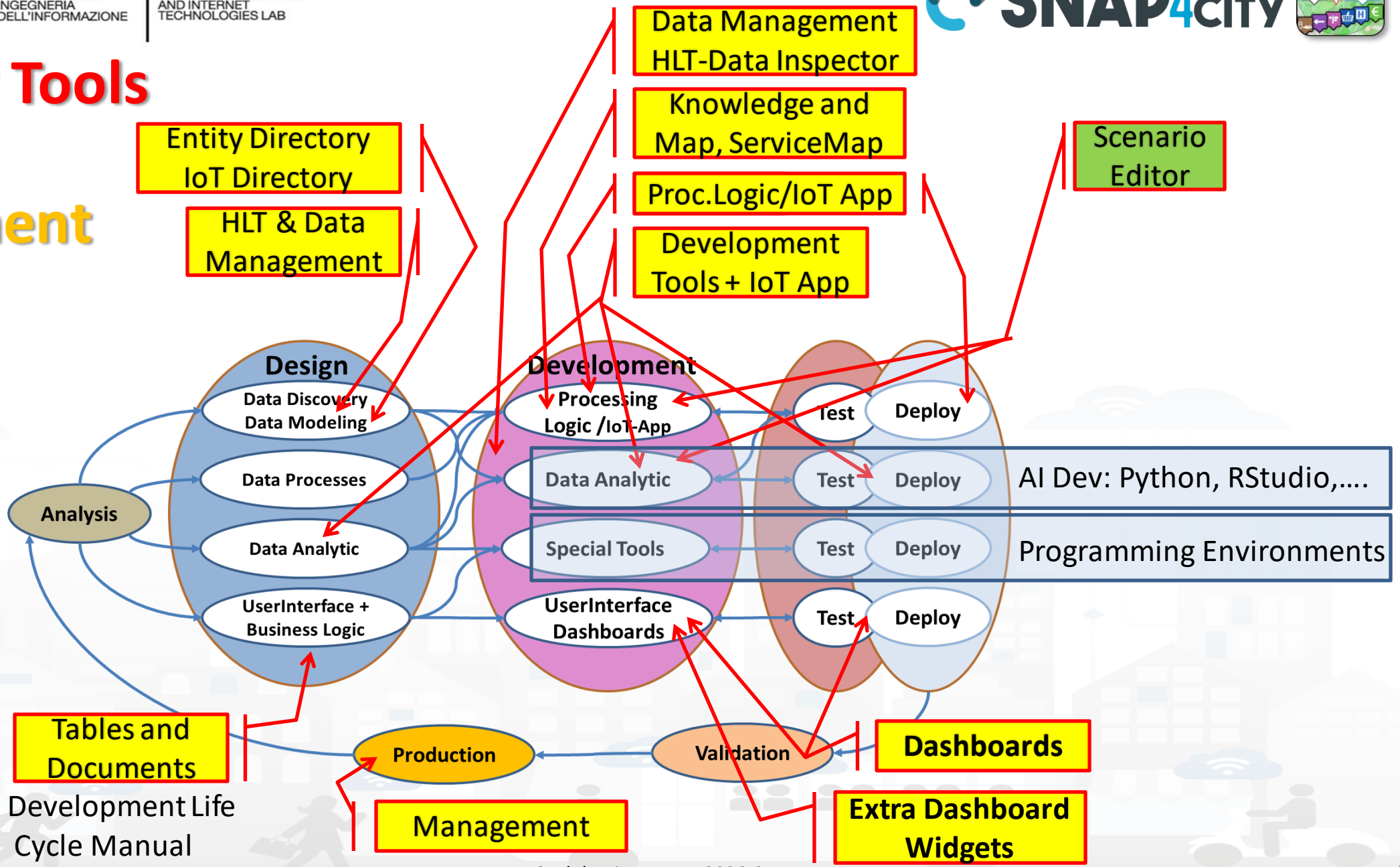
Agile Development Life Cycle by sprint Smart Solutions

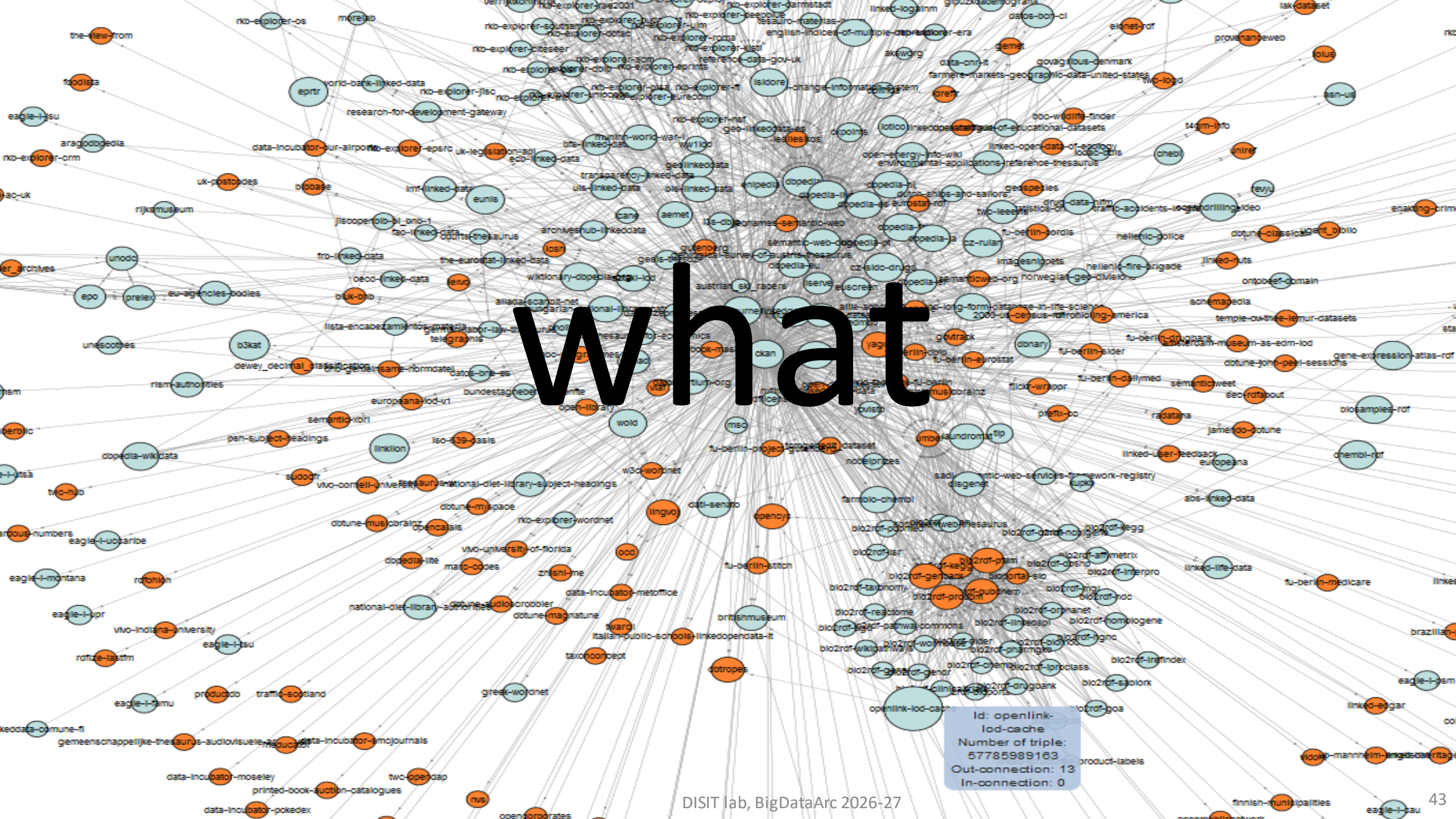


Development Life Cycle Smart Solutions

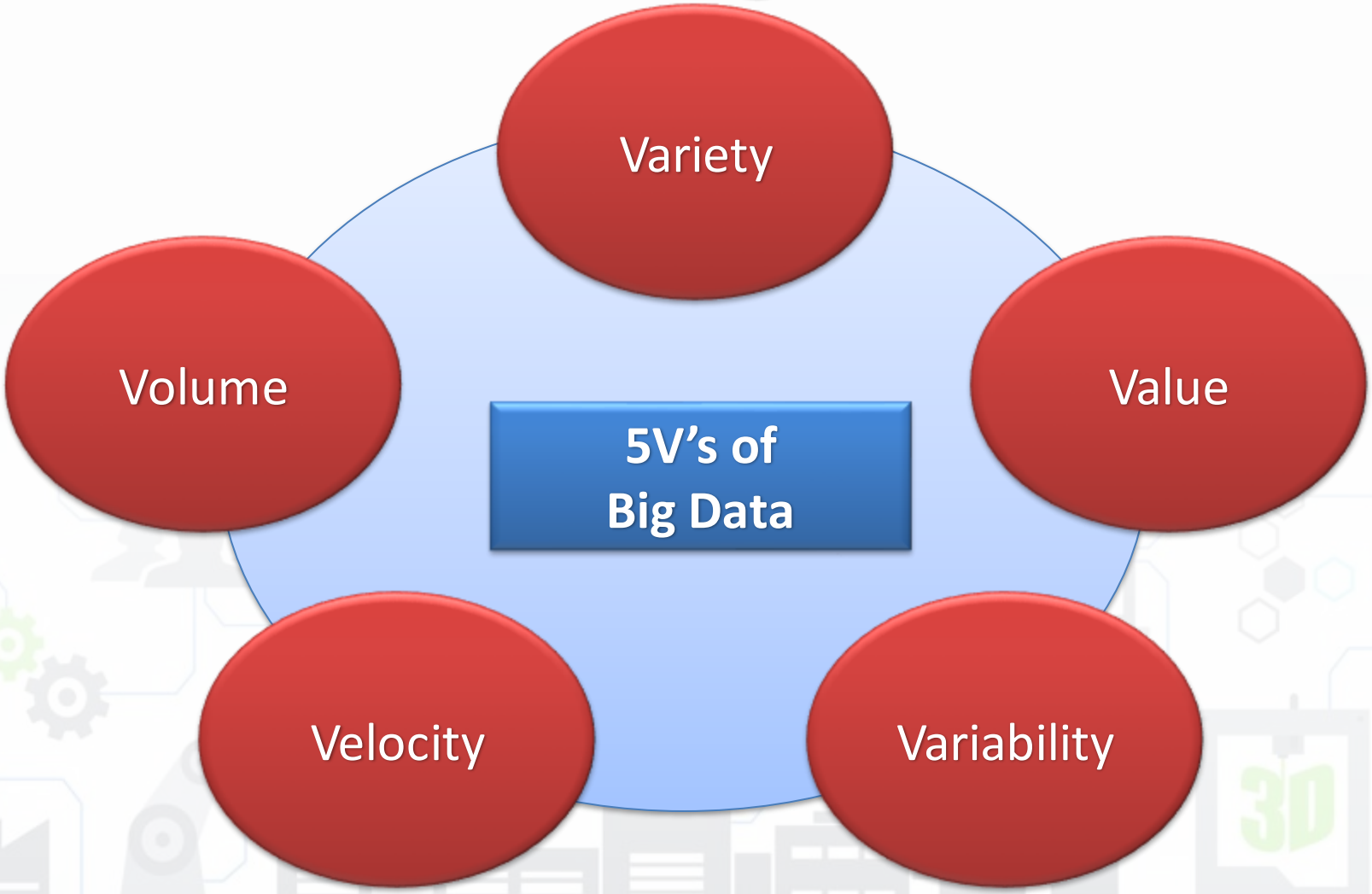


Snap4City Tools vs Development Life Cycle

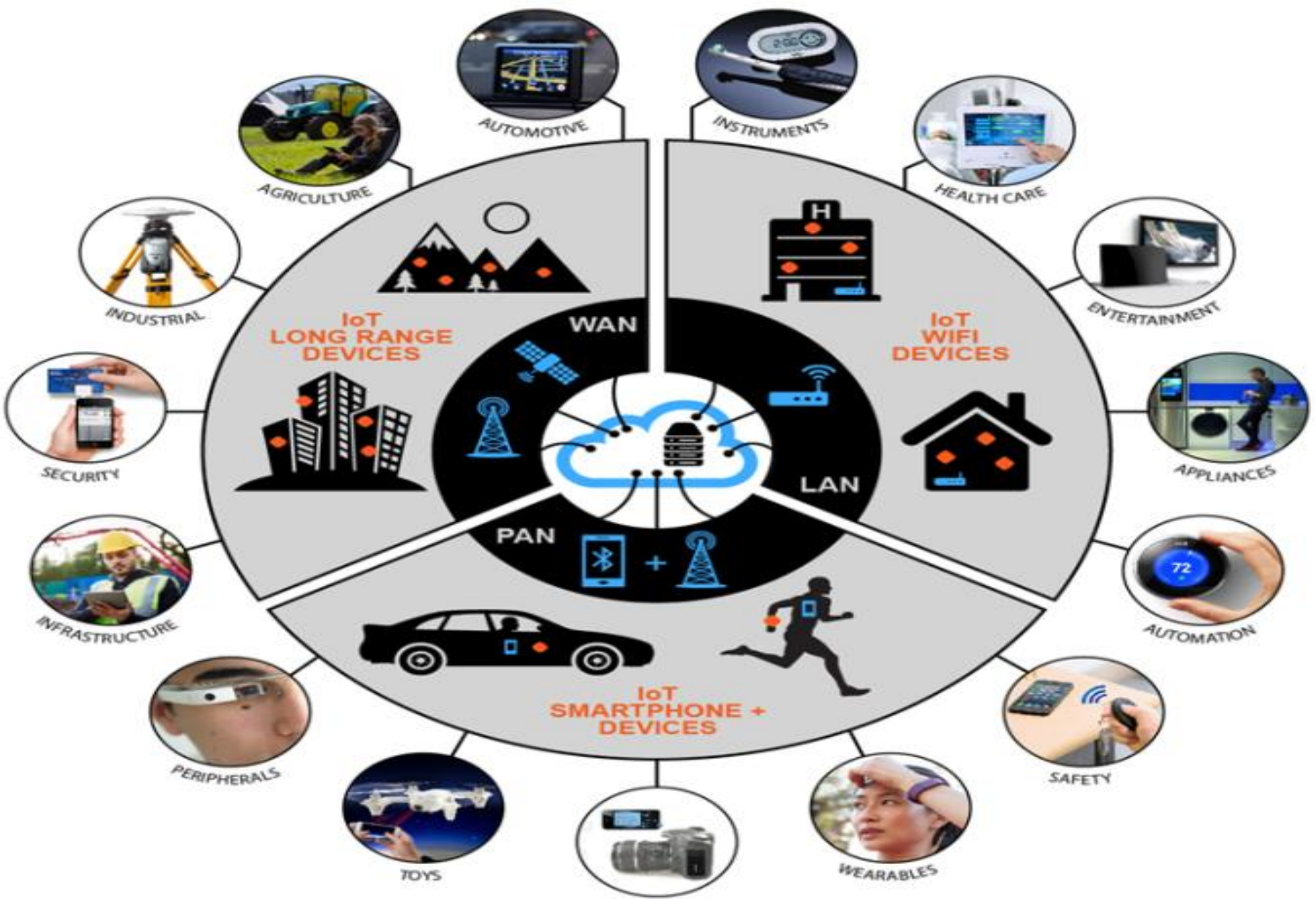



what
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

5V of Big Data

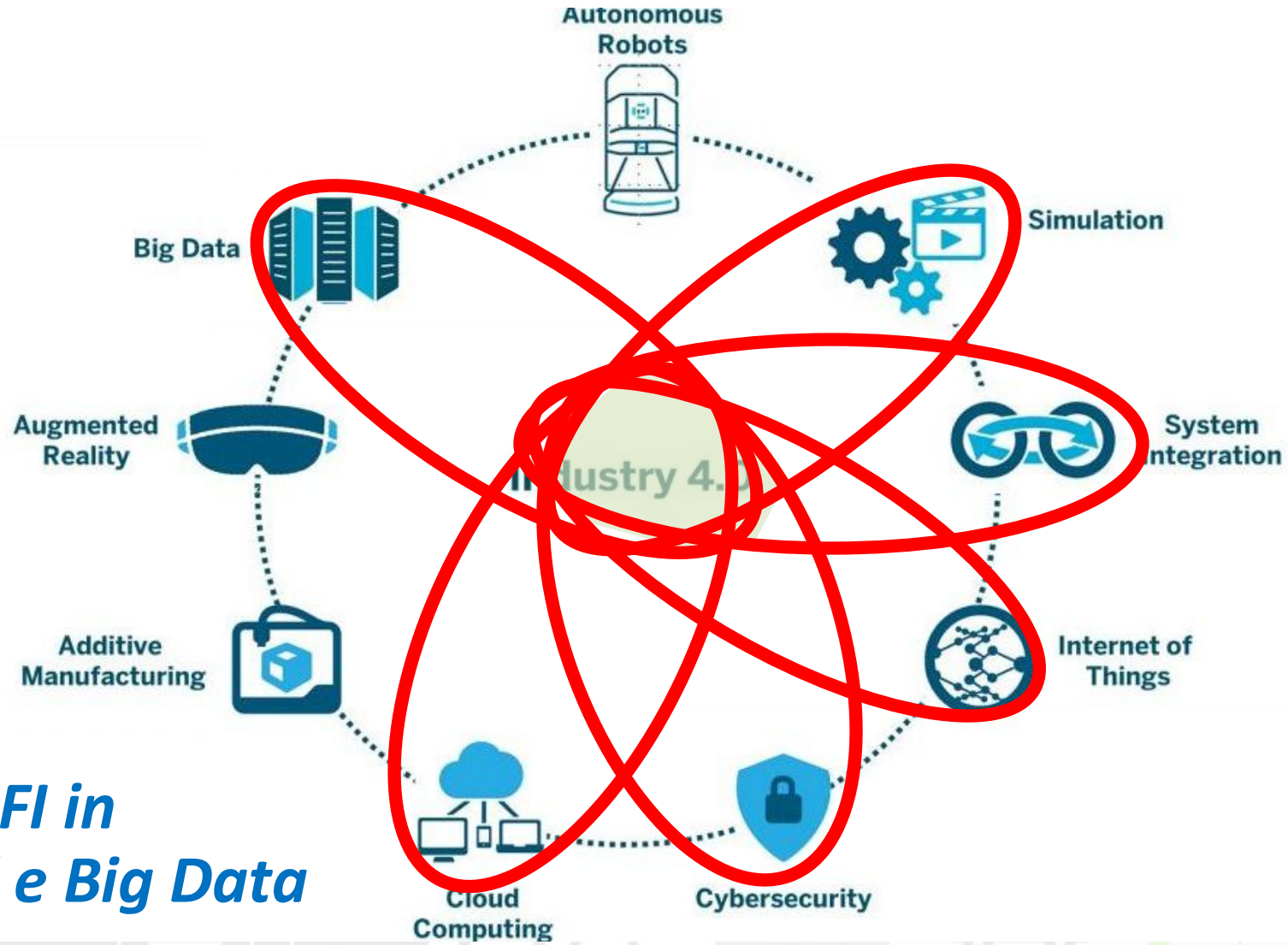


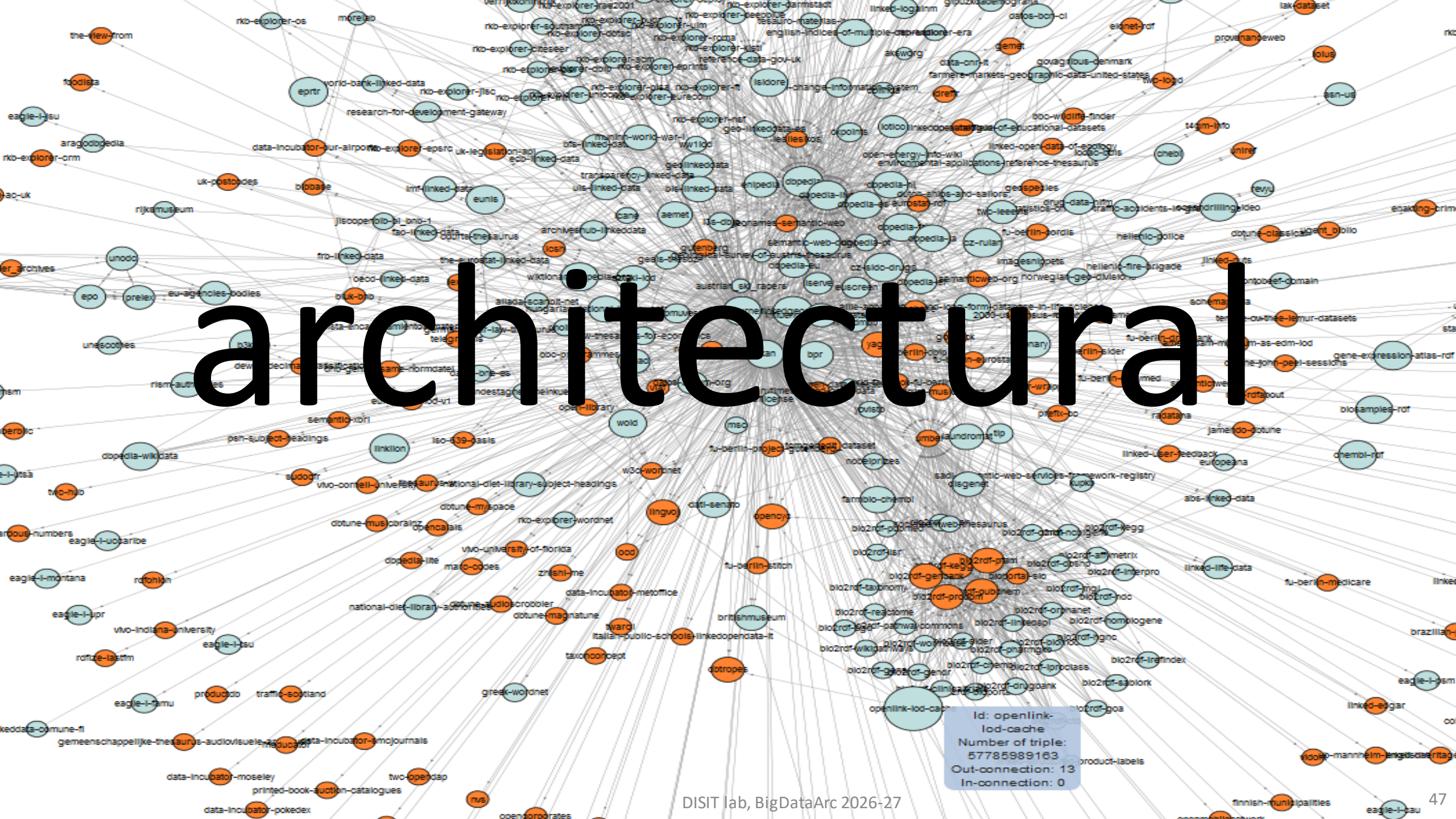
Bia Data & Analytics



Industria 4.0 vs DISIT Lab

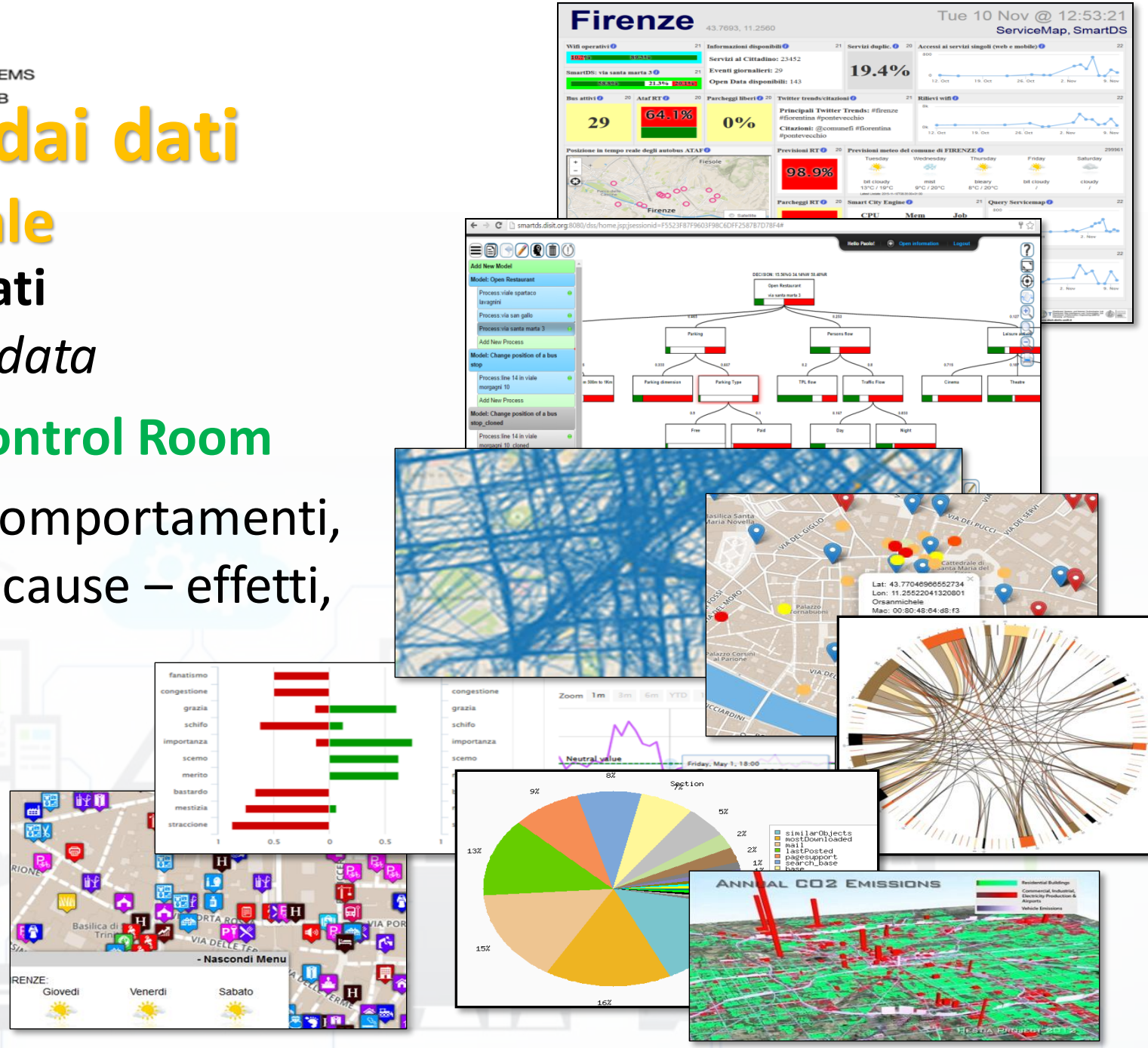
- Big Data
- Cloud Computing
- Cybersecurity
- IOT/IOE
- System Integration
- Simulation
- +
- Data Analytics
- ***P. Nesi è referente per UNIFI in RegioneToscana per Cloud e Big Data***



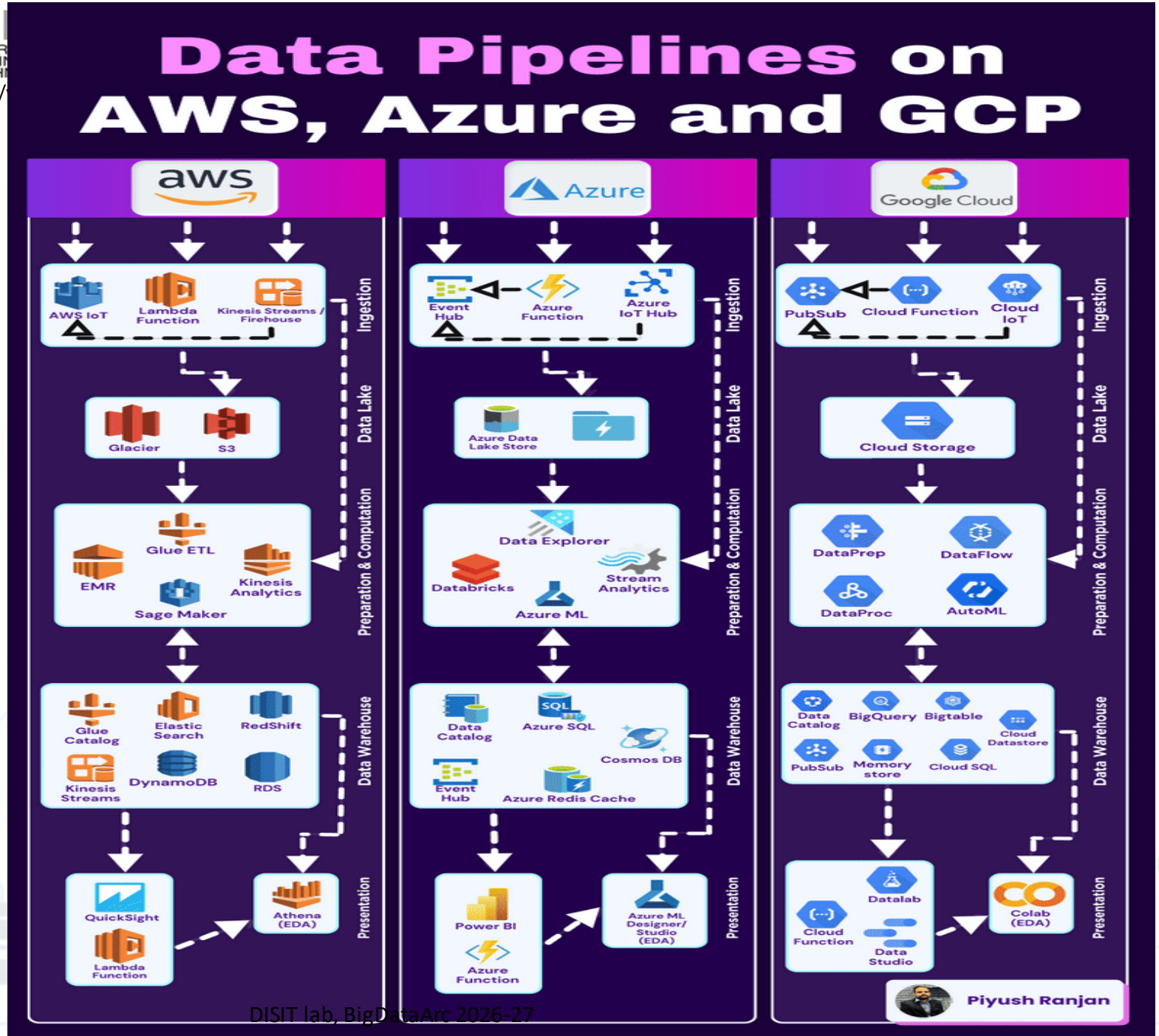

architectural
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

Decisioni supportate dai dati periodiche ed in tempo reale

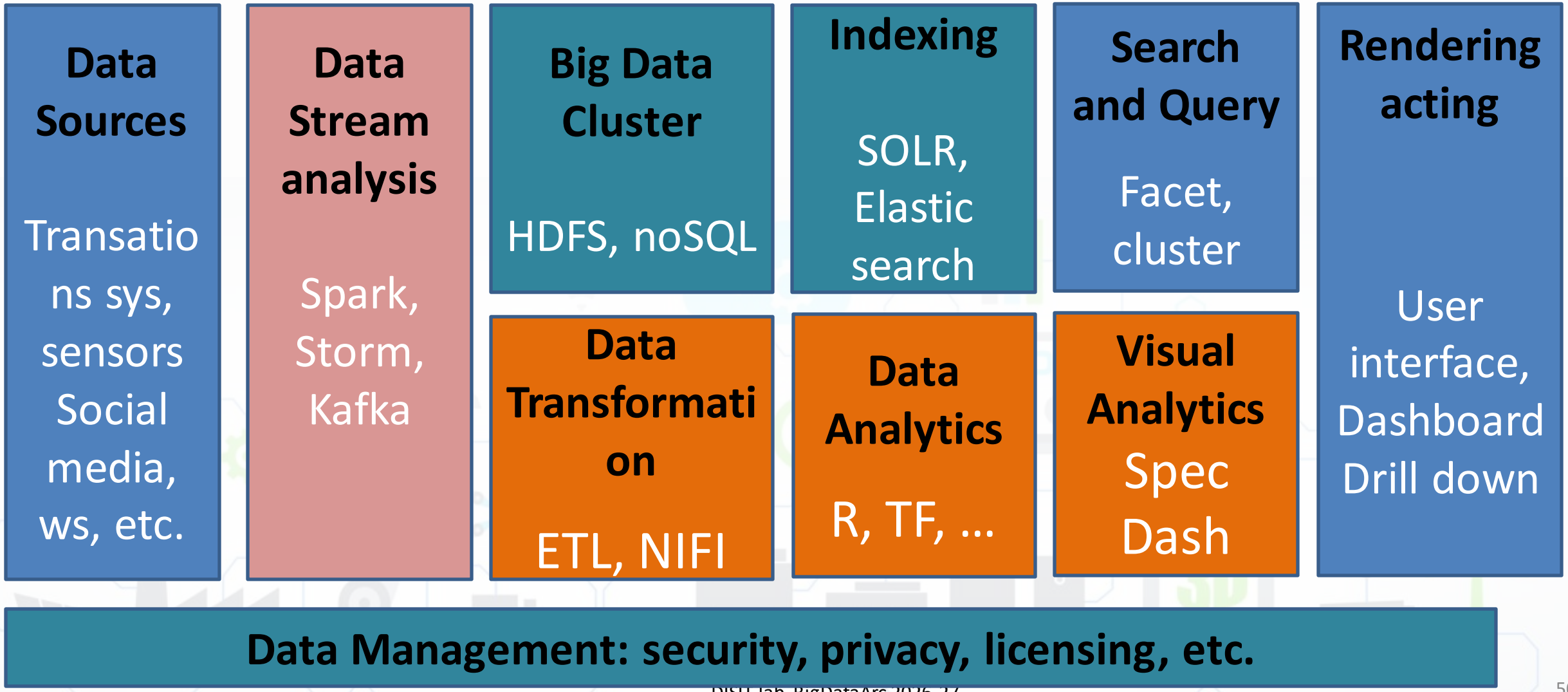
- **Condivisione e Integrazione Dati multidominio:** *semantica e bigdata*
- **Dati → Smart City Engine → Control Room**
- **analisi**: monitoraggio, flussi e comportamenti, sondaggi, mining, correlazioni, cause – effetti, etc.
  - Per il miglioramento di servizi correnti
  - Per reagire ad eventi, incremento della resilienza,
  - Per la creazione servizi innovativi



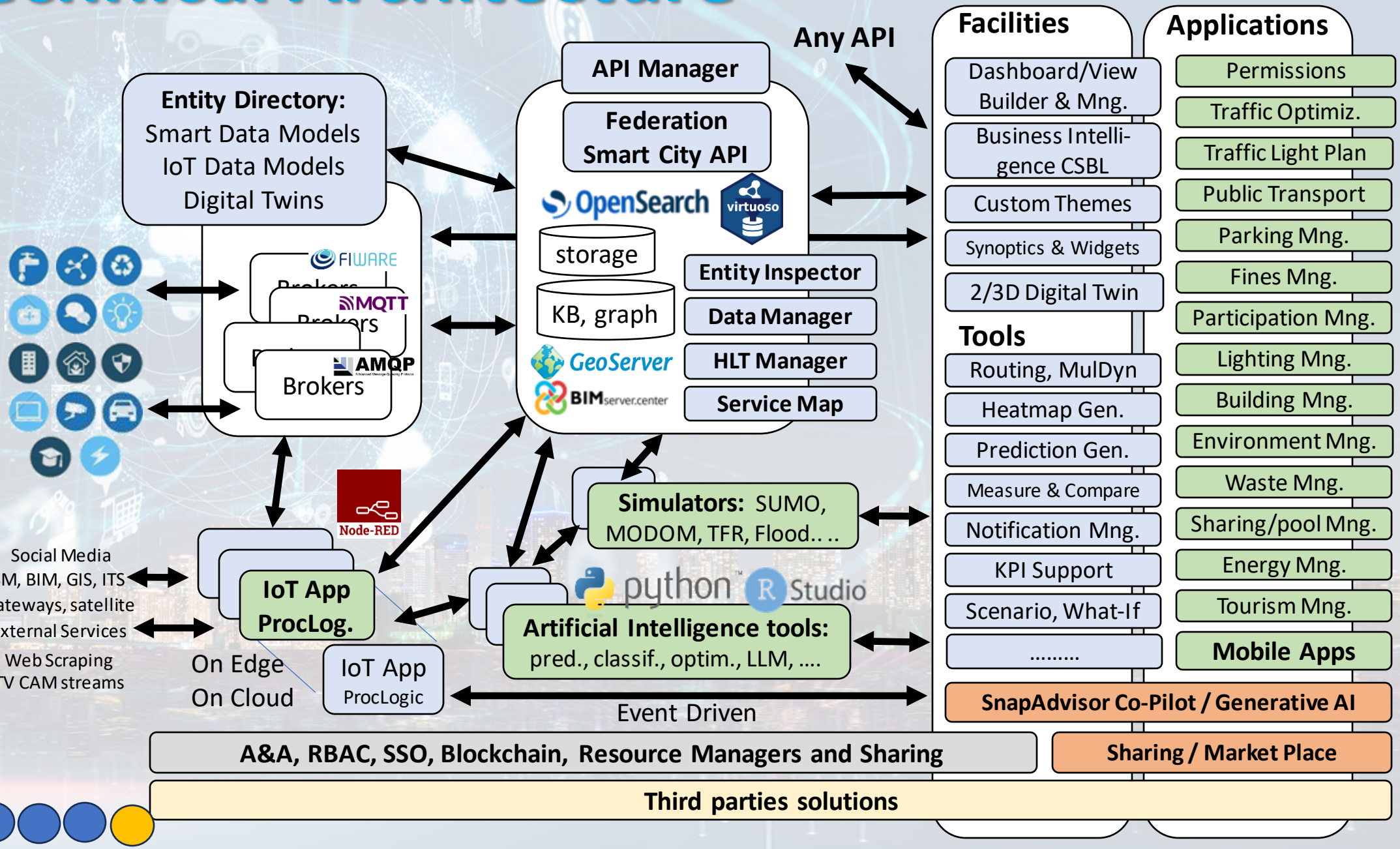
Analisi e confronto di grandi architetture



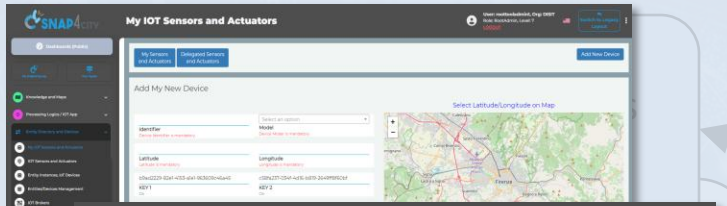
Architettura di base Big Data, IOT, Industry 4.0

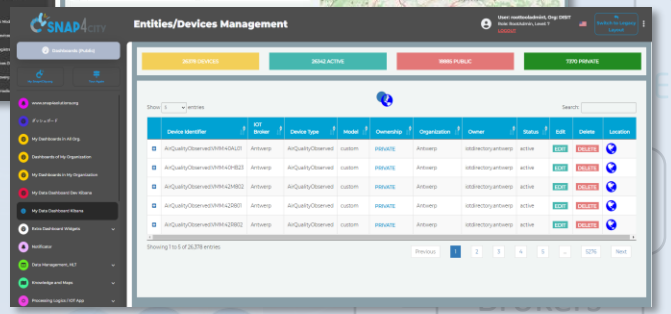


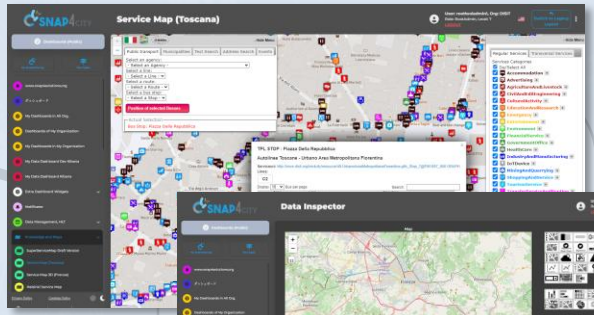
Technical Architecture

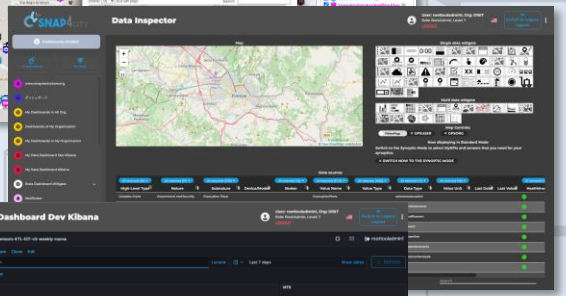


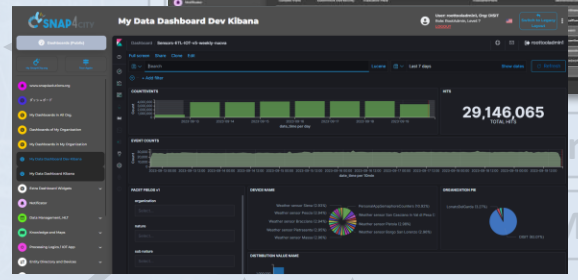
Visual Development Tools

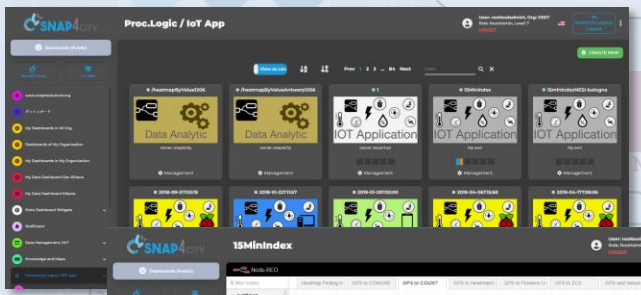


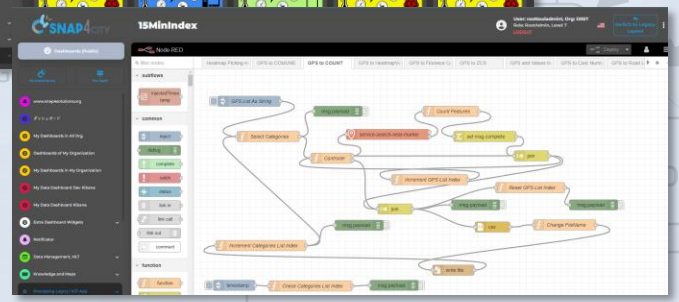


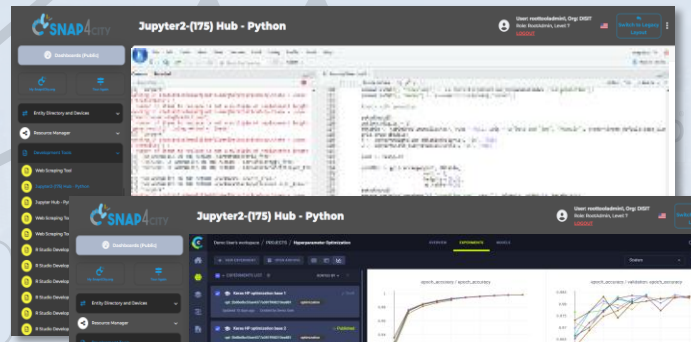


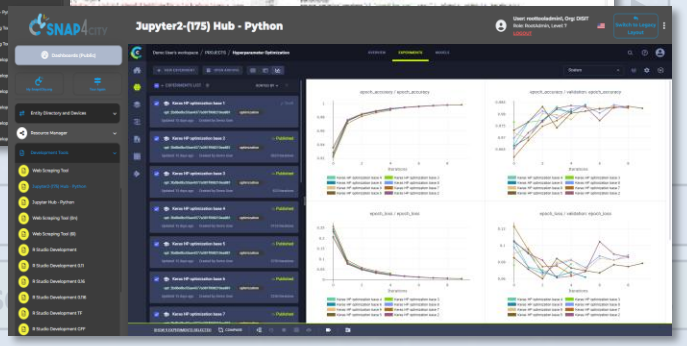


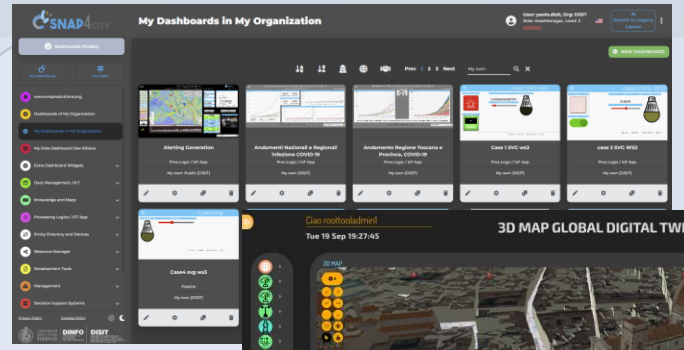




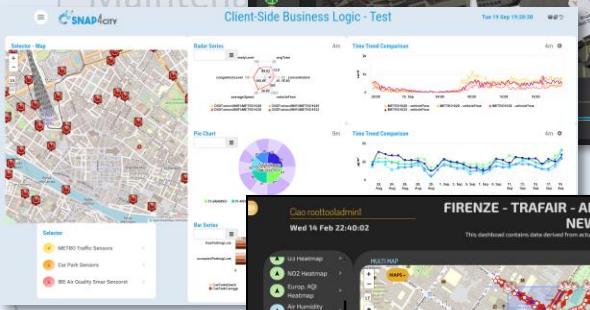


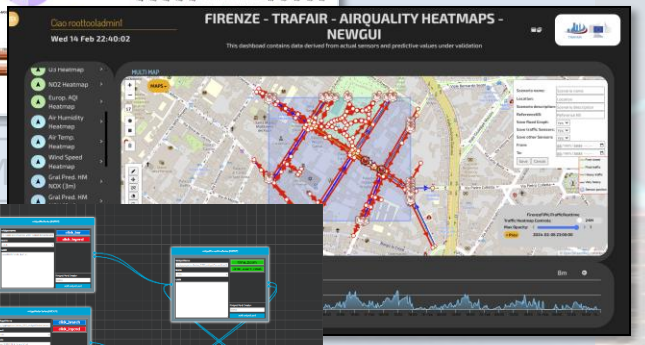


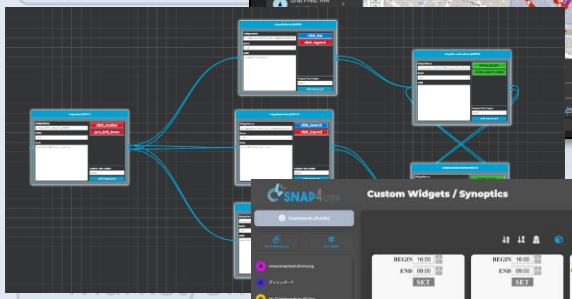




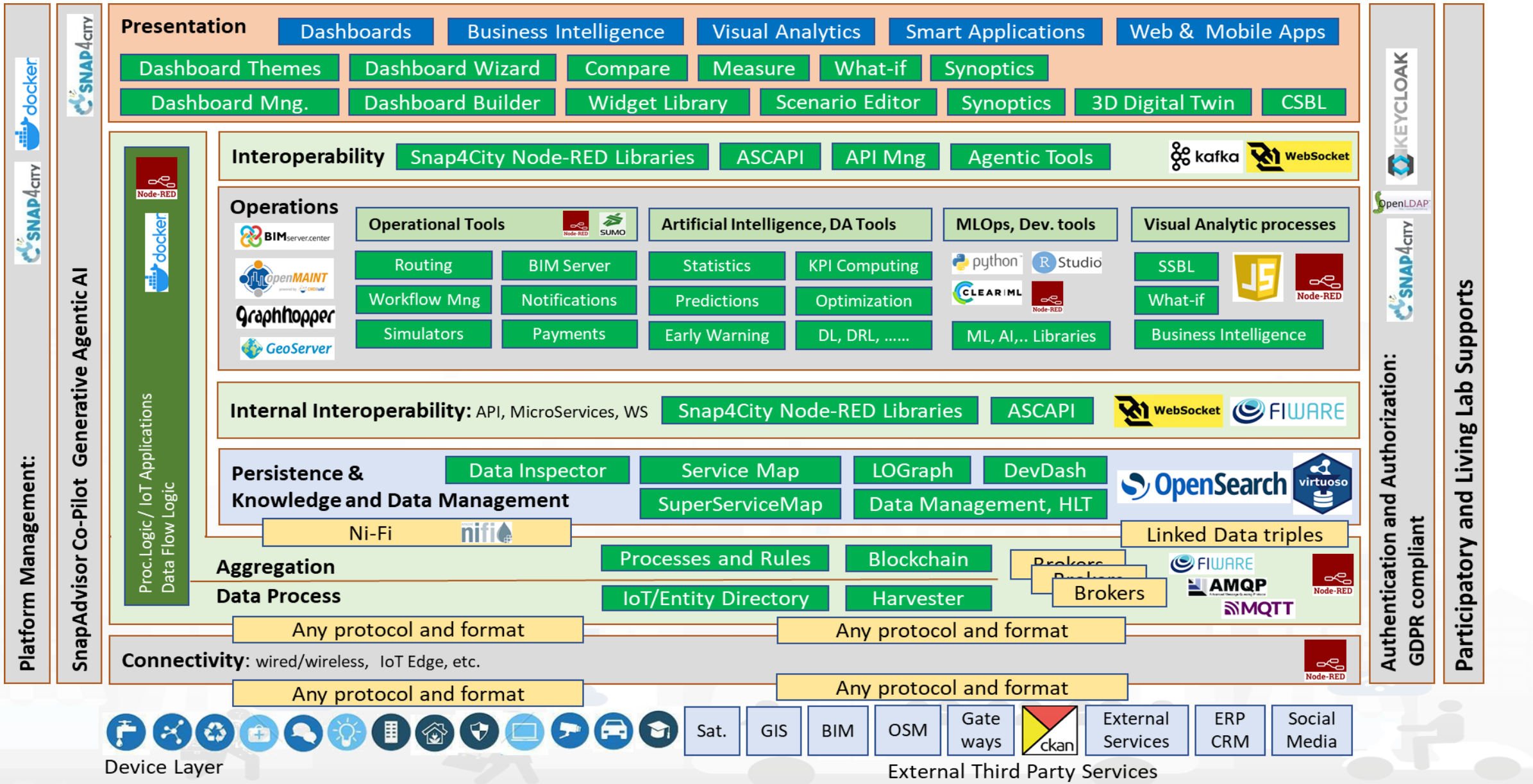


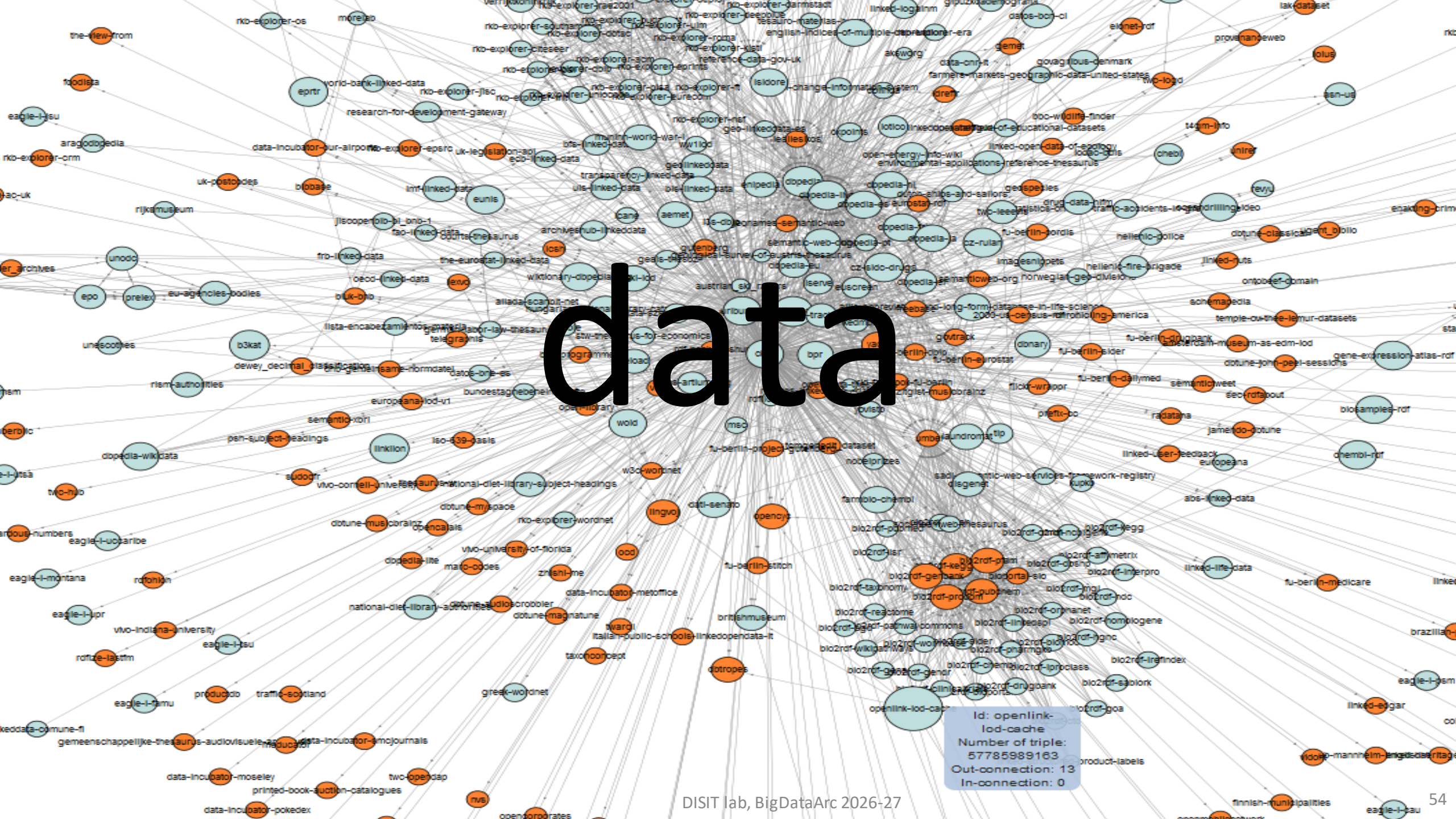









Platform Management:
SnapAdvisor Co-Pilot Generative Agentic AI
Presentation
Dashboards
Business Intelligence
Visual Analytics
Smart Applications
Web & Mobile Apps
Dashboard Themes
Dashboard Wizard
Compare
Measure
What-if
Synoptics
Dashboard Mng.
Dashboard Builder
Widget Library
Scenario Editor
Synoptics
3D Digital Twin
CSBL
Interoperability
Snap4City Node-RED Libraries
ASCAPI
API Mng
Agentic Tools
kafka
WebSocket
Operations
Operational Tools
Artificial Intelligence, DA Tools
MLOps, Dev. tools
Visual Analytic processes
Routing
BIM Server
Statistics
KPI Computing
Workflow Mng
Notifications
Predictions
Optimization
Simulators
Payments
Early Warning
DL, DRL, ...
ML, AI,.. Libraries
SSBL
What-if
Business Intelligence
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
Ni-Fi
Linked Data triples
Proc.Logic / IoT Applications Data Flow Logic
Aggregation
Data Process
Processes and Rules
Blockchain
IoT/Entity Directory
Harvester
Brokers
FIWARE
AMQP
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
Sat.
GIS
BIM
OSM
Gate ways
ckan
External Services
ERP CRM
Social Media
External Third Party Services
Authentication and Authorization: GDPR compliant
KEYCLOAK
OpenLDAP
Participatory and Living Lab Supports


data
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

Privati Statici

- Codice fiscale
- Foto non condivise
- Aspetti legali
- Cartella clinica
- ..

- Movimenti personali non pubblicati
- Relazioni personali non pubblicate

Pubblici statici (open data)

statistiche: incidenti, censimenti, votazioni

- Statistiche accessi alla ZTL
- Strutture pubbliche UNIFI

posizione dei punti di interesse

- Musei
- Strutture della città
- Servizi attivi

- comportamenti
- social media
- contributi
- consumi

- Traffico personale
- Posizione mezzi,
- Parcheggi
- Posizione taxi
- Posizione CarSharing …

Privati Tempo reale

- Info traffico
- video camere
- Info Meteo
- Info Ambiente
- Code ai musei pubblici
- Terremoti
- Parcheggi

- Stato accessi alla ZTL
- Stato dei servizi

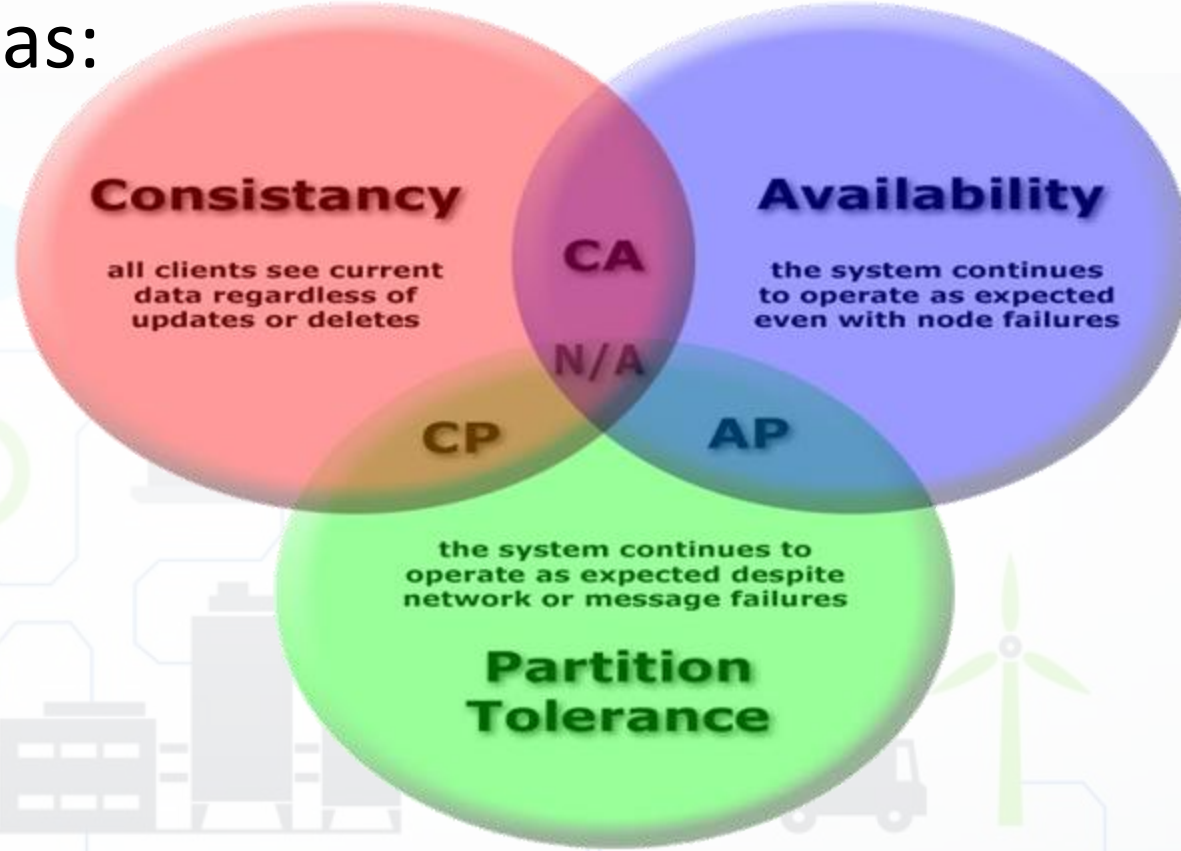
Pubblici Tempo reale (open data)

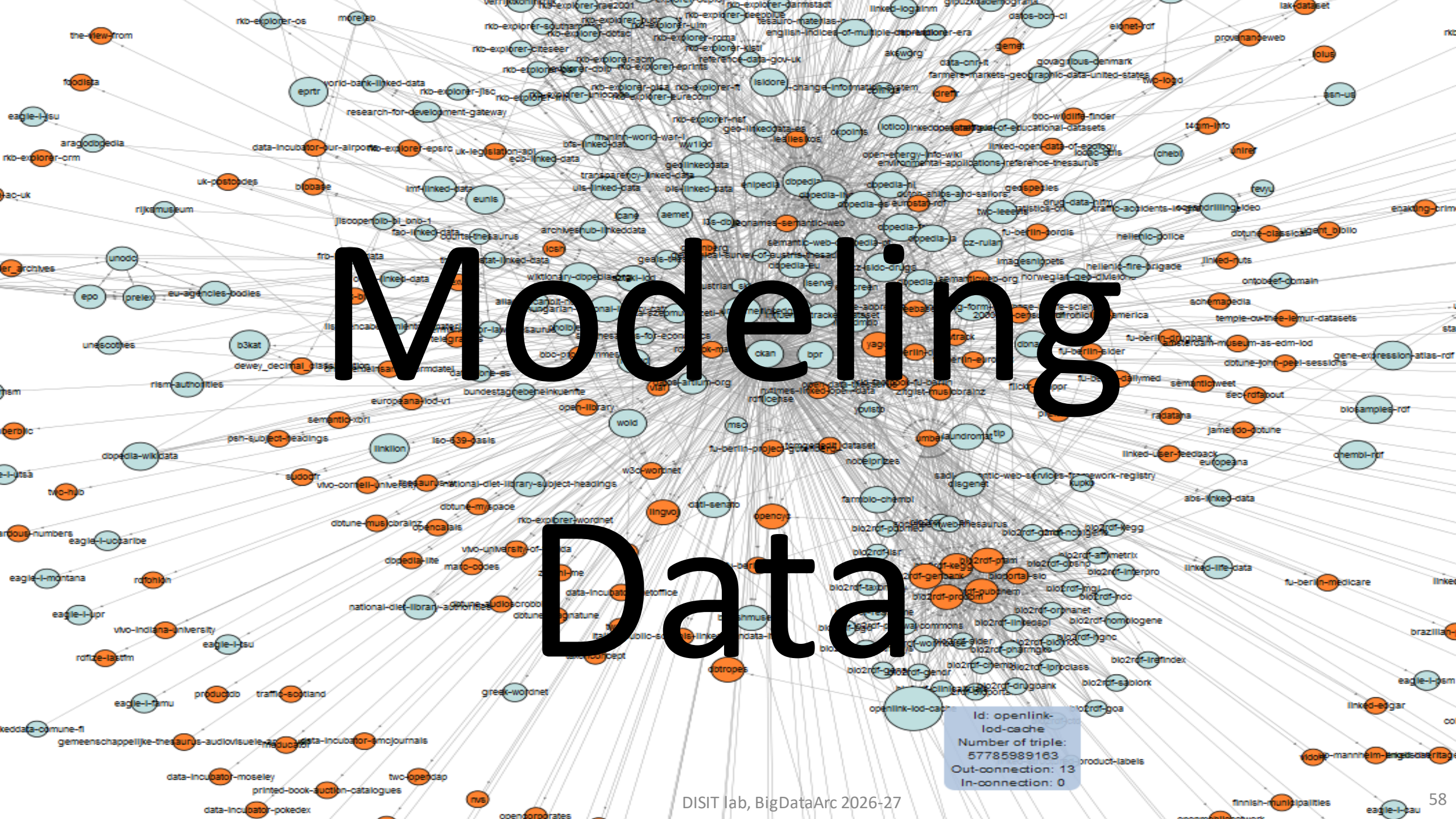
Complessità del Dato

- **Formati diversi, valori sparsi e discontinui** anche in stream
  - Data healthiness, integrity, etc.
- Tecniche: Data Lake per la normalizzazione del dato
  - → big data graveyards based on HDFS
- **Formati e dati non riferibili in modo preciso alla stessa semantica** delle entità in gioco: temperatur*e*, coordinat*e*, misure dei sensori in generale, … → molto dipendenti dal contesto
  - Modelli ontologici → ontologie → knowledge base → expert systems, per ricerche in chiave semantica, Riconciliazione semantica, completamento, contestualizzazione, …

CAP theorem

- The **CAP theorem** (Consistency - Availability - Partition tolerance) is essential to **understand** the **behavior** of **distributed SW systems**, and **how** to **design** the **architecture** in order to meet stringent requirements, such as:
  - High **performance**.
  - Continued **availability**.
  - **Geographically distributed** systems.
- Working on billions and trillions of day, **scalability** became a key concept.



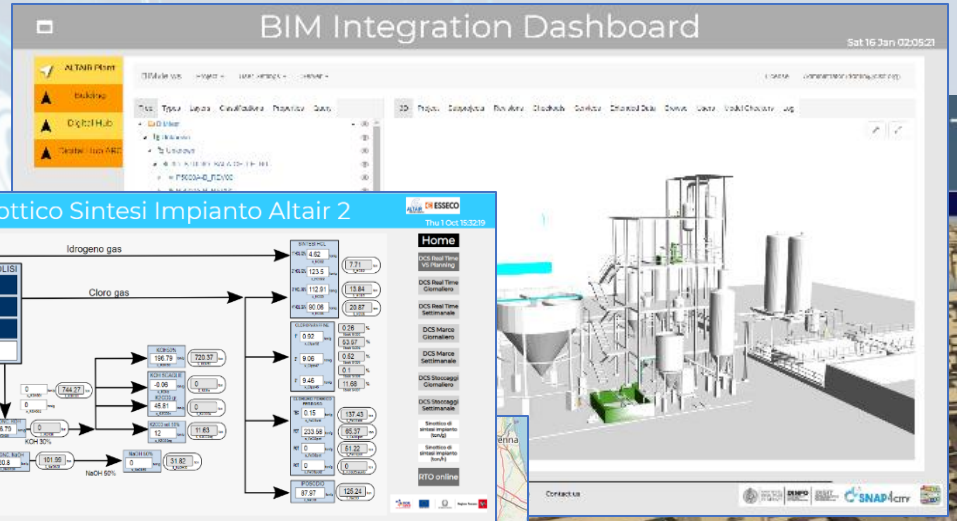

Modeling
Data
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

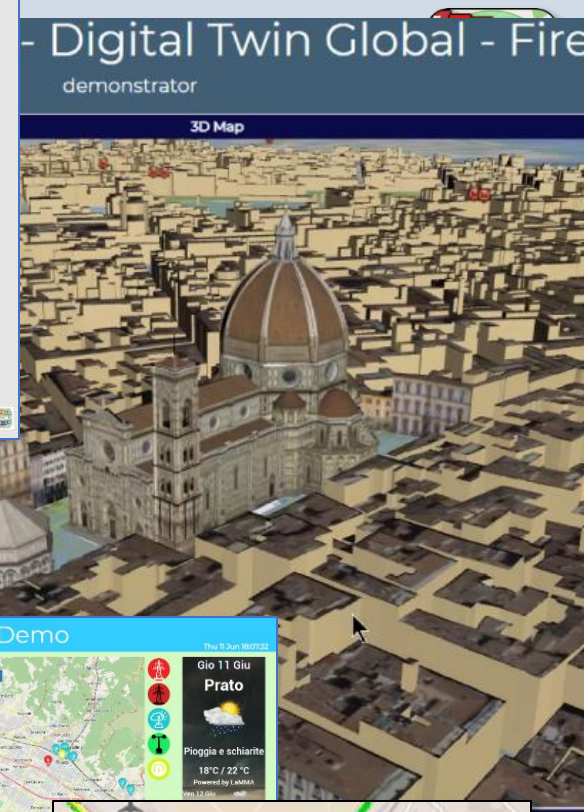
High Level Types

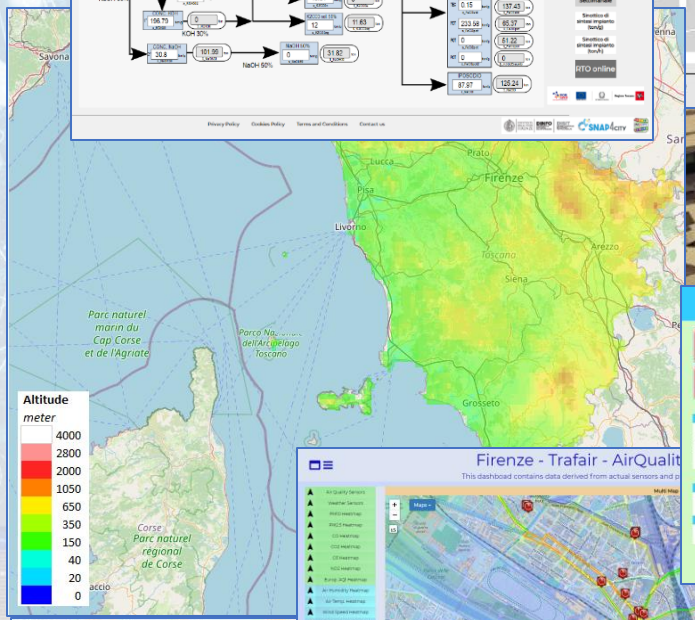
DISIT lab, BigDataArc 2026-27

- POI, IOT Devices, shapes,..
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, any kind..
- traffic flow, typical trends, ..
- Vector fields + heatmaps, ..
- 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, ..
- scenarios, ….
- etc.



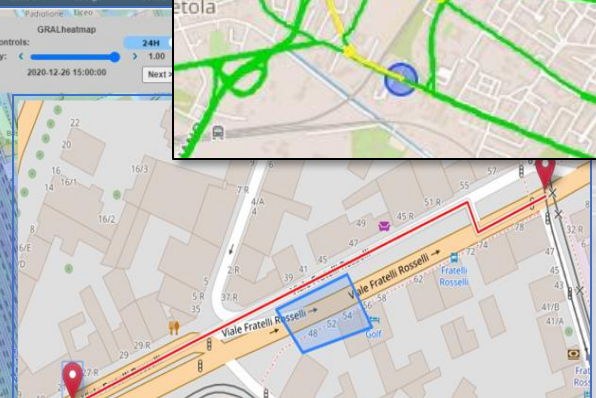












Km4City Ontology elements 1.6.8





- **Km4C**: Km4City 1.6.8
- Using
  - **DCTERMS**: for metadata Dublin Core Metadata Initiative
  - **FOAF**: friends of a friends
  - **Good Relation**: entities relationships
  - **iot-lite**: IOT Vocabuary
  - **OTN**: Ontology of Transportation Networks
  - **OWL-Time**: time reasoning
  - **SAREF** Smart Appliances REFerence extension for building devices available at https://saref.etsi.org/saref4bldg/
  - **Schema.org** for people and organizations
  - **SSN**: Semantic Sensor Network Ontology (see https://www.w3.org/TR/vocab-ssn/
  - **WGS84** Datum of Geo-Objects
  - **GTFS**, General Transit Feed Specification, and **Transmodel**, for public transport infrastructures: lines/rides time schedules, real-time records, paths, etc.;
  - **BOT**: Building Topology Ontology. https://w3c-lbd-cg.github.io/bot/
  - **S4CITY**: SAREF extension for Smart City. https://saref.etsi.org/saref4city/v1.1.2/

Standards and Interoperability

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, WCS, RTSP, ONVIF, AXIS TVCam, CISCO Meraki, OSM, Copernicus, The Weather Channel, Open Weather, OLAP, VMS Milestone, TIM, HERE, OGC, ….
- **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.

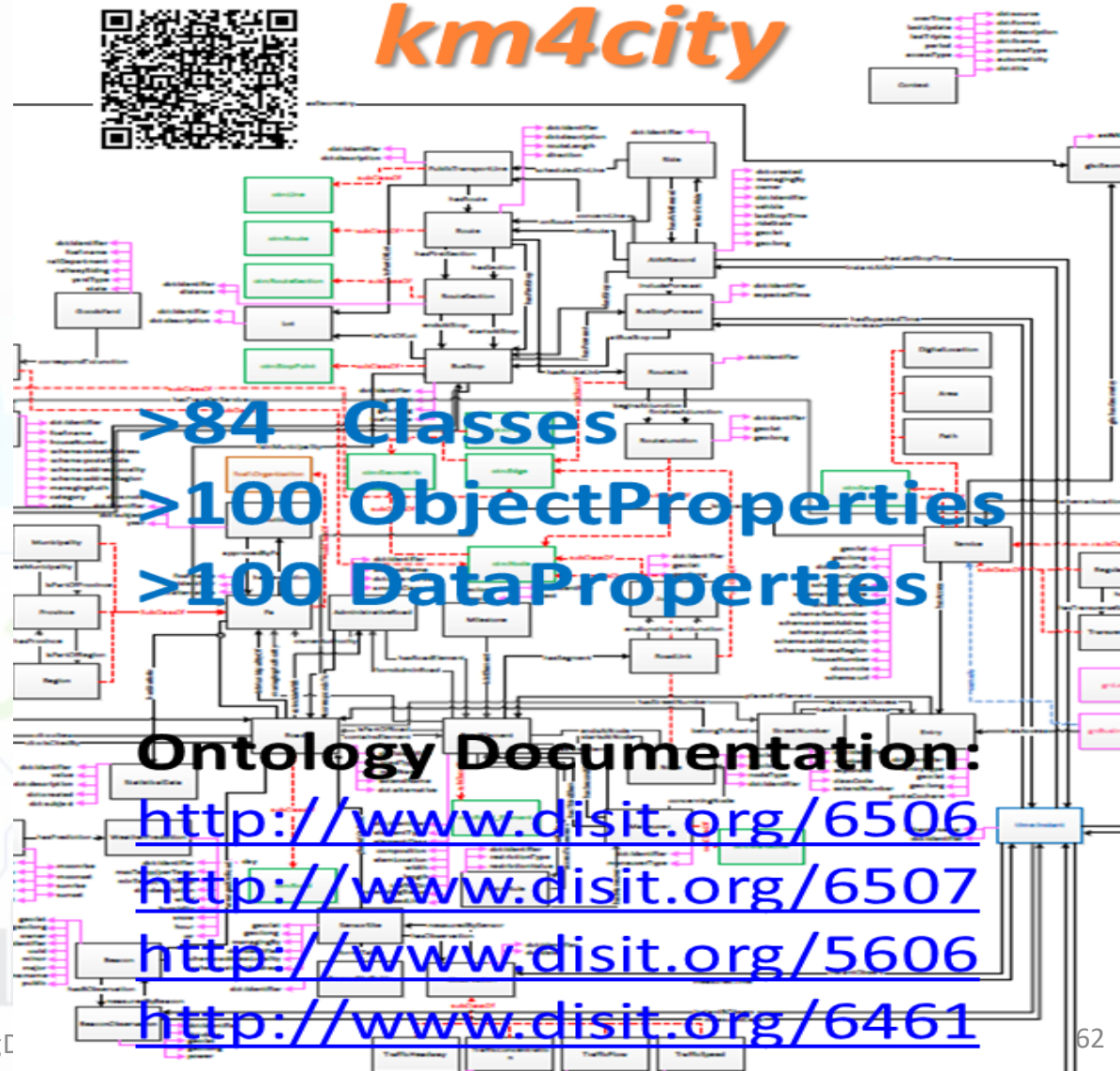
https://www.snap4city.org/65

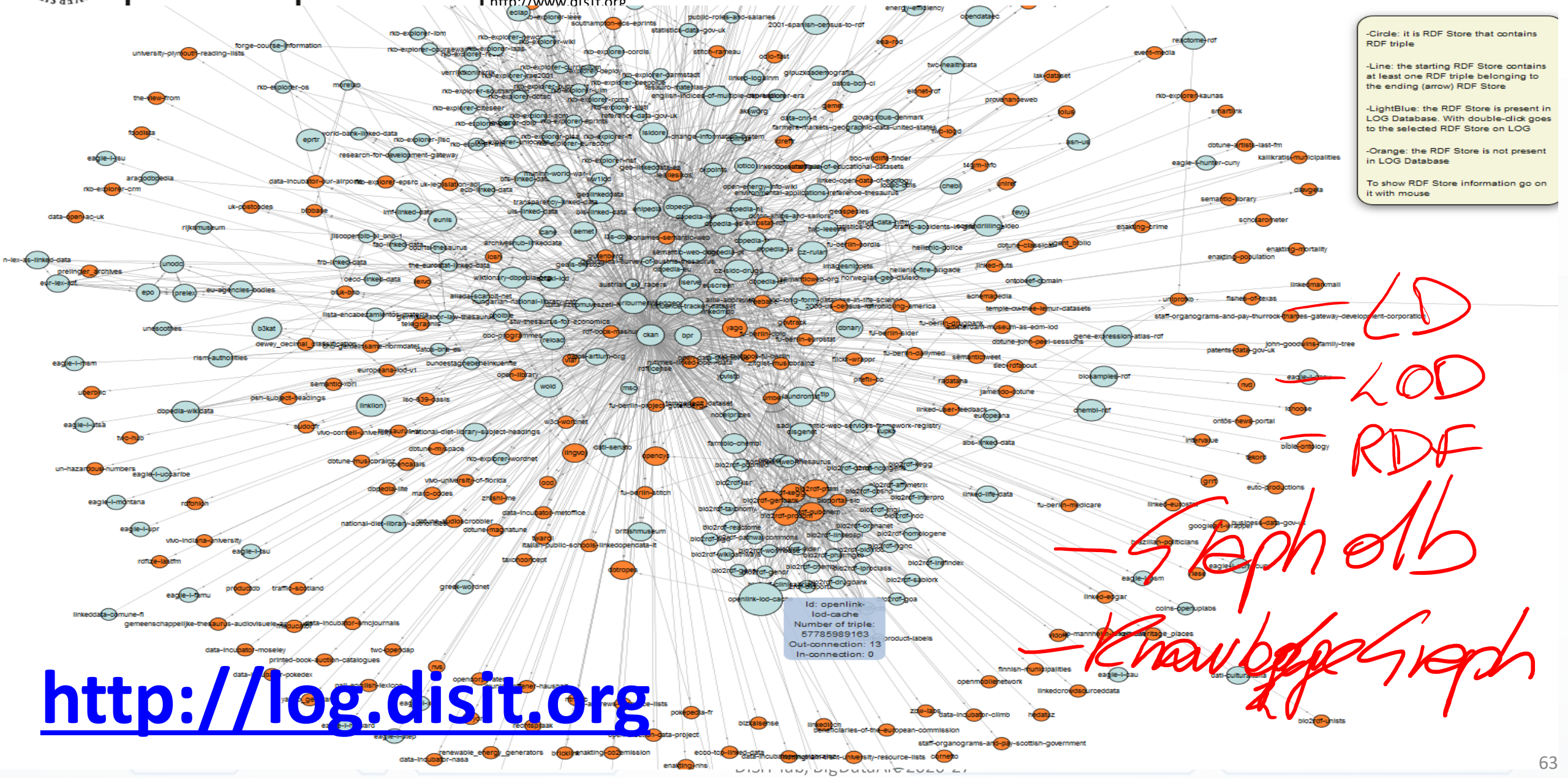
I Dati

- **Collezionamento dati** statici, quasi statici e real time, stream
  - **Dati open**: geo localizzati, servizi, statistiche, censimenti, etc.
  - **Dati privati degli operatori**: con licenze limitate per non permettere di fare profitto ad altri operatori sulla base dei loro dati
  - **Dati personali delle persone**: profili, comportamenti tramite APP, IOT, sensori, web, etc.
- **Integrazione dati per renderli *semanticamente interoperabili***, ed operare deduzioni (time, space…)
  - I tradizionali ***collettori di open data*** danno visioni statistiche ma **non sono adatti a produrre servizi integrati**
  - ***Integrazione con modelli semantici unificanti come Km4City***

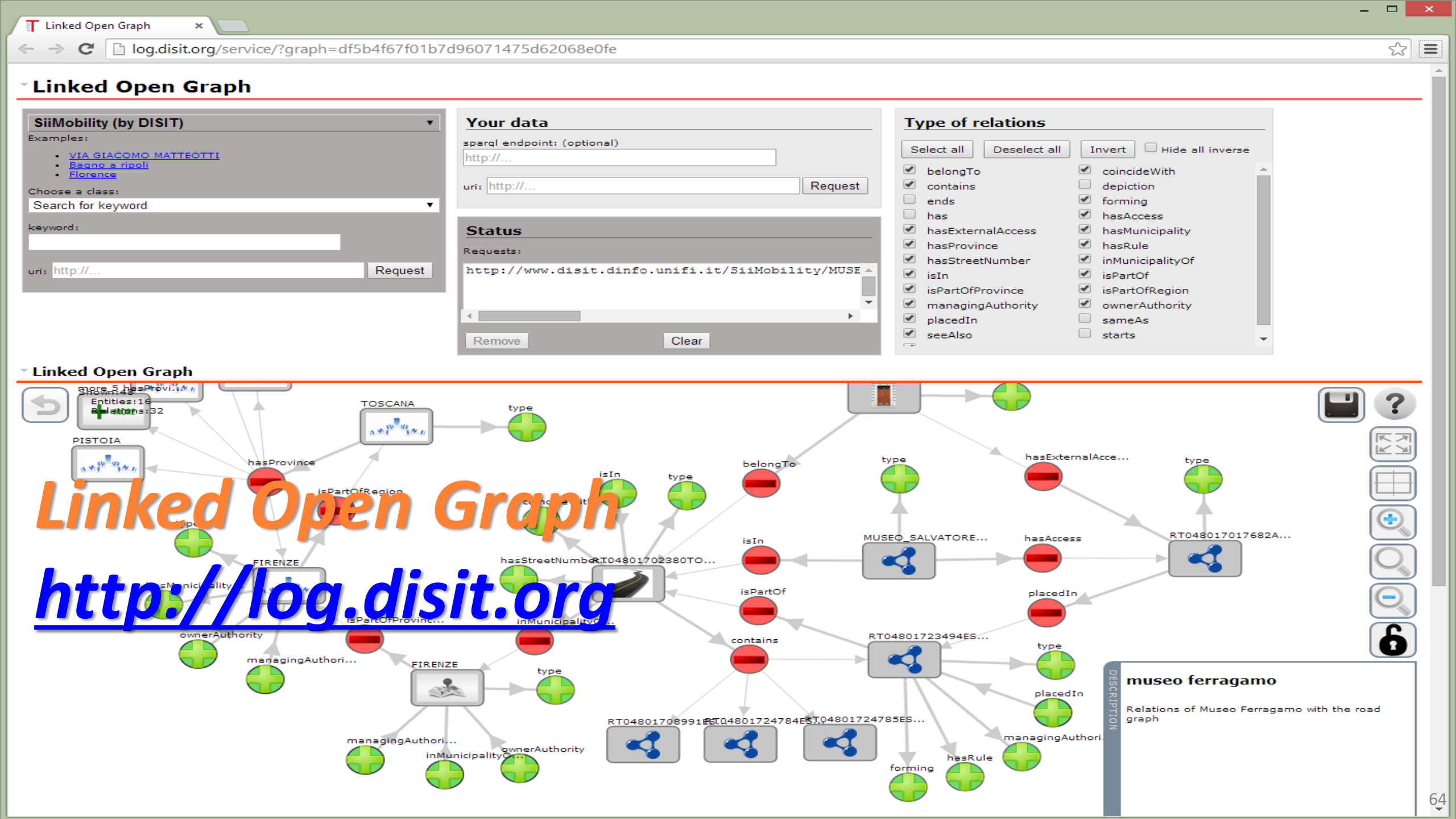
S-P-O

Smart-city Ontology km4city



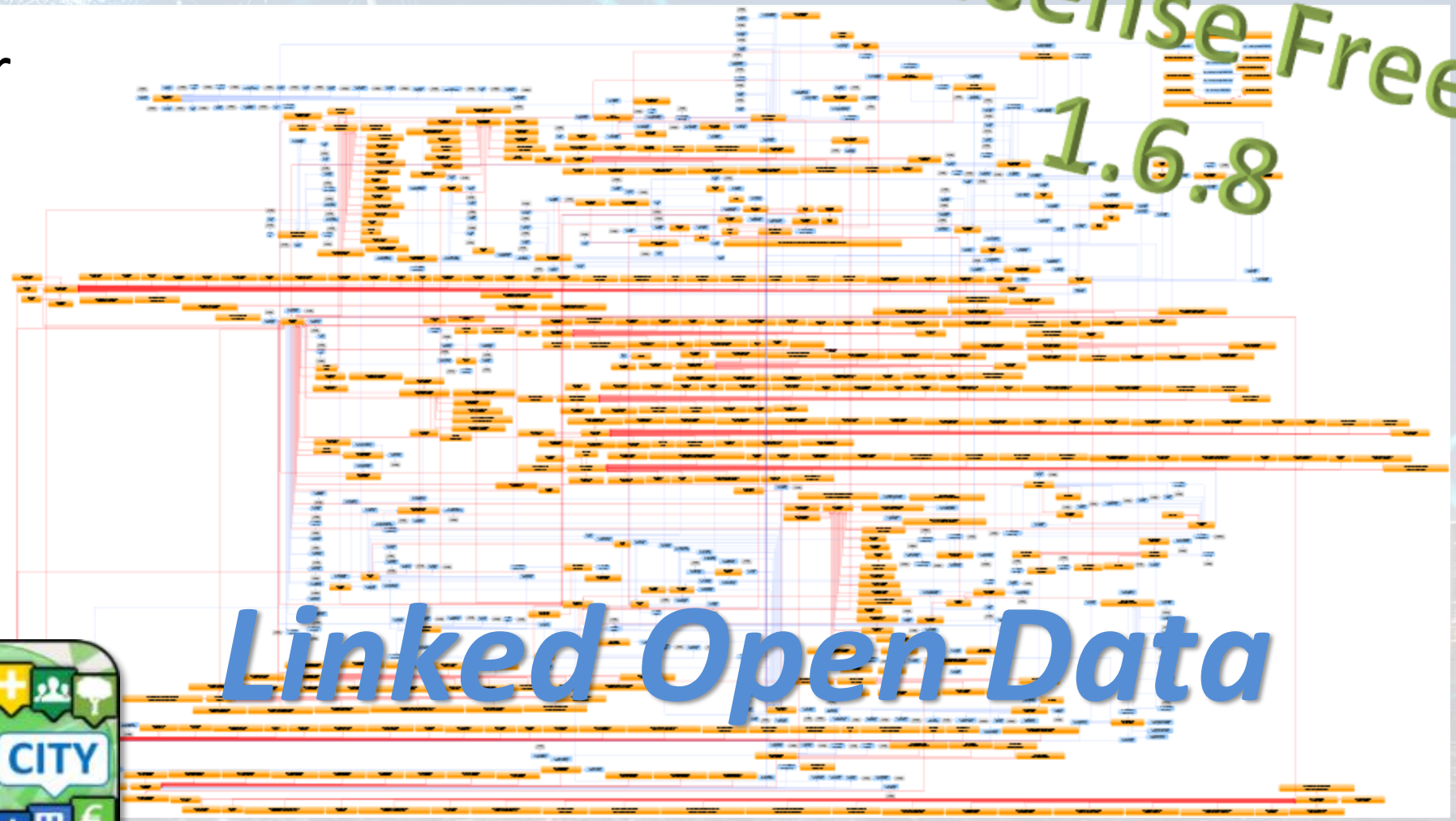


http://log.disit.org

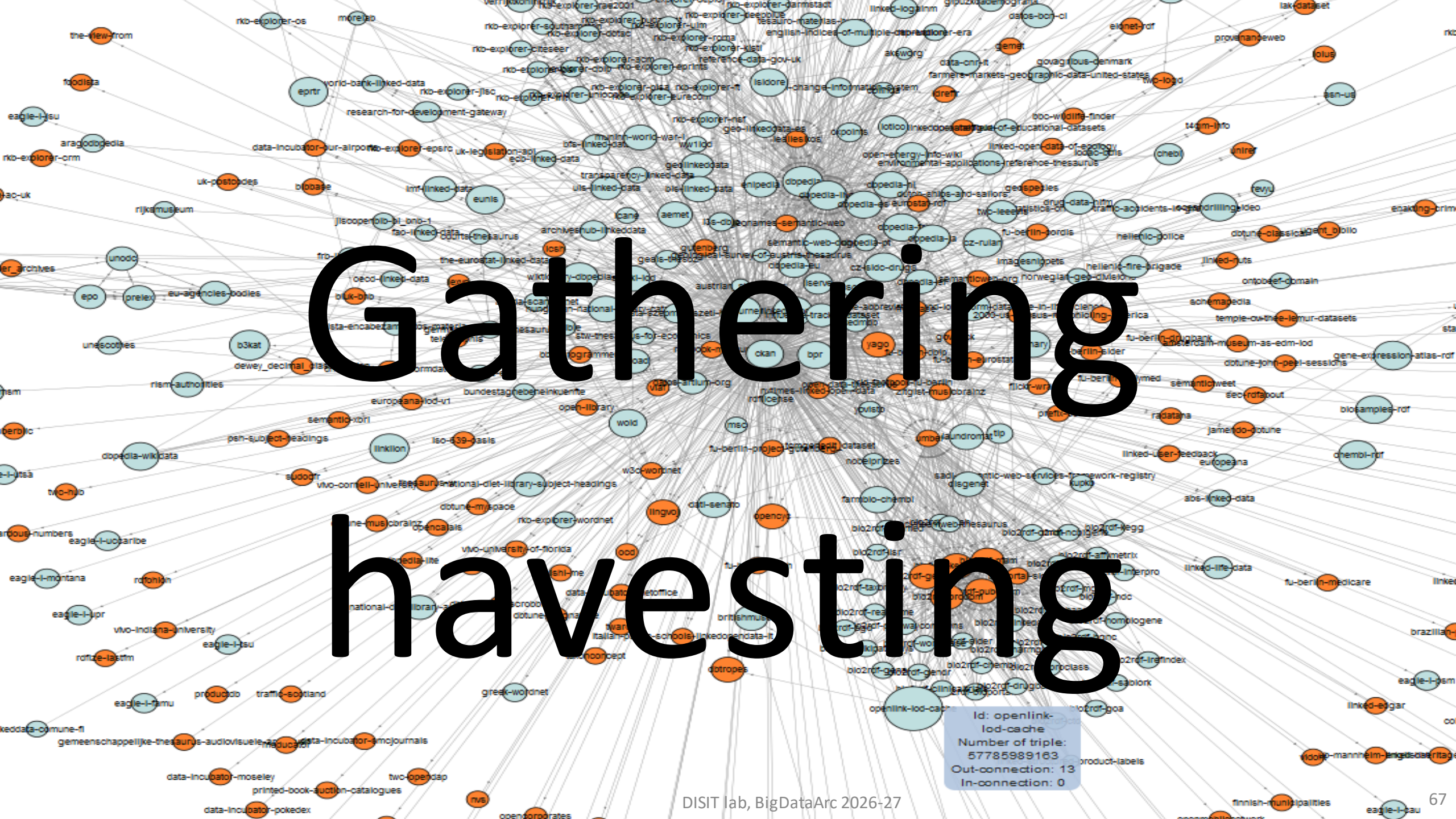

Linked Open Graph
log.disit.org/service/?graph=df5b4f67f01b7d96071475d62068e0fe
Linked Open Graph
SiiMobility (by DISIT)
Examples:
VIA GIACOMO MATTEOTTI
Bagno a ripoli
Florence
Choose a class:
Search for keyword
keyword:
uri: http://...
Request
Your data
sparql endpoint: (optional)
http://...
uri: http://...
Request
Status
Requests:
http://www.disit.dinfo.unifi.it/SiiMobility/MUSE
Remove
Clear
Type of relations
Select all
Deselect all
Invert
Hide all inverse
belongTo
contains
ends
has
hasExternalAccess
hasProvince
hasStreetNumber
isIn
isPartOfProvince
managingAuthority
placedIn
seeAlso
coincideWith
depiction
forming
hasAccess
hasMunicipality
hasRule
inMunicipalityOf
isPartOf
isPartOfRegion
ownerAuthority
sameAs
starts
Linked Open Graph
Shown:45
Entities:16
Relations:32
TOSCANA
type
PISTOIA
hasProvince
isPartOfRegion
isIn
type
belongTo
type
hasExternalAcce...
type
FIRENZE
hasStreetNumber
RT048017023801O...
isIn
MUSEO_SALVATORE...
hasAccess
RT048017017682A...
isPartOf
placedIn
ownerAuthority
managingAuthori...
contains
RT04801723494ES...
type
FIRENZE
type
placedIn
RT048017089918
RT04801724784ES...
RT04801724785ES...
managingAuthori...
ownerAuthority
inMunicipalityO...
forming
hasRule
managingAuthori...
DESCRIPTION
museo ferragamo
Relations of Museo Ferragamo with the road graph
Linked Open Graph
http://log.disit.org

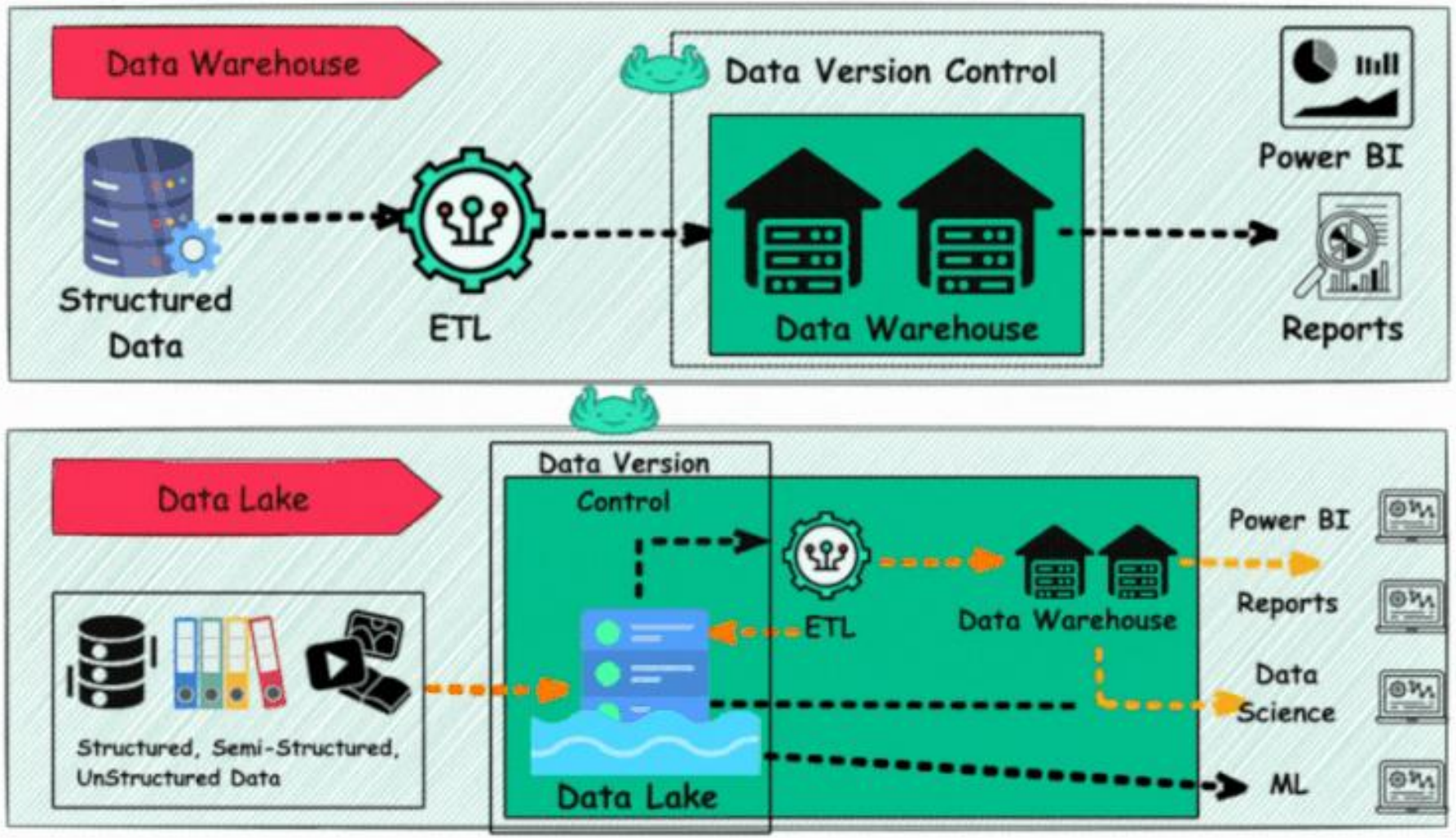
Expert System semantic queries

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

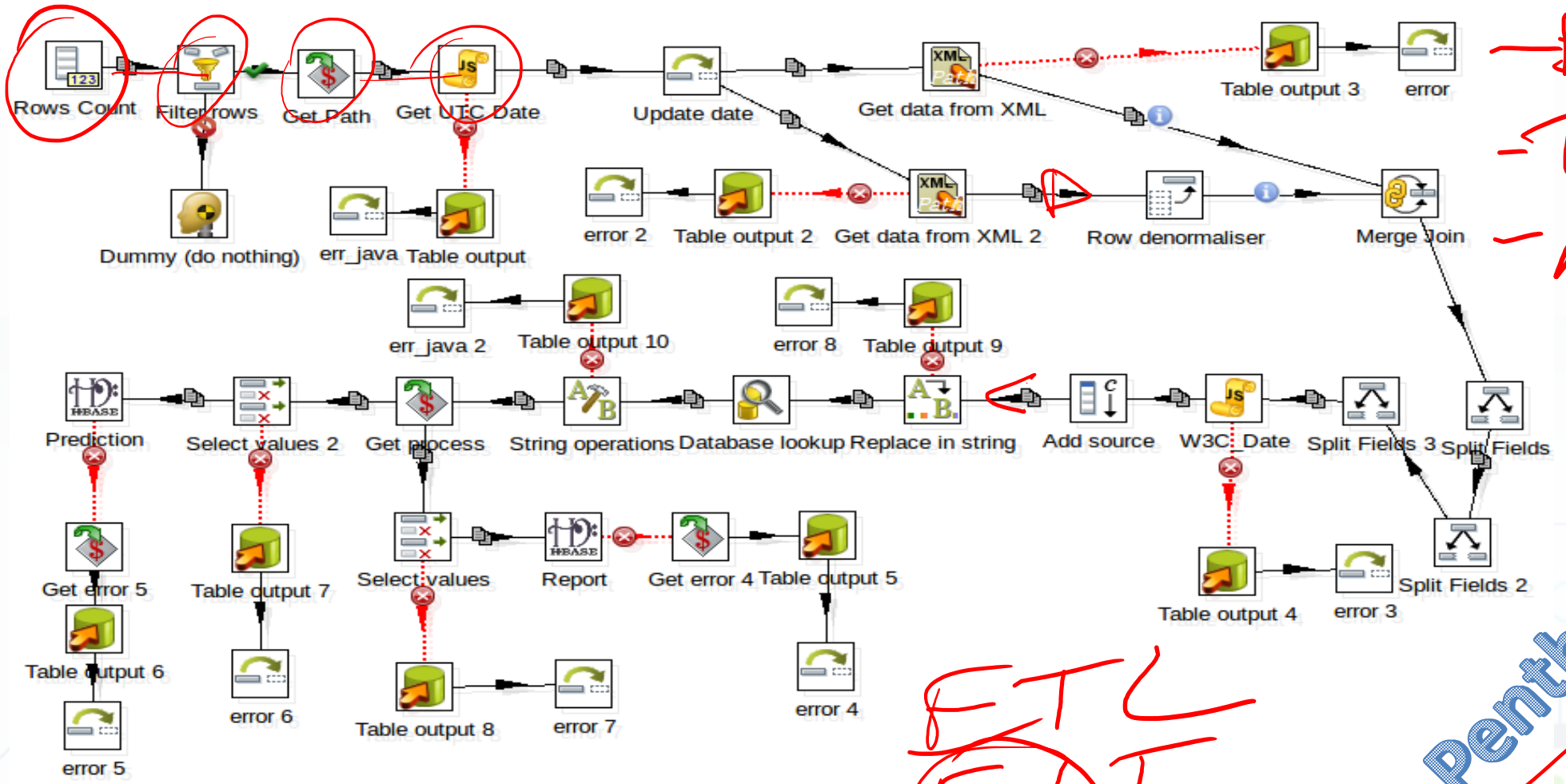


https://www.snap4city.org/19


Gathering
havesting
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0


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

Example of ETL

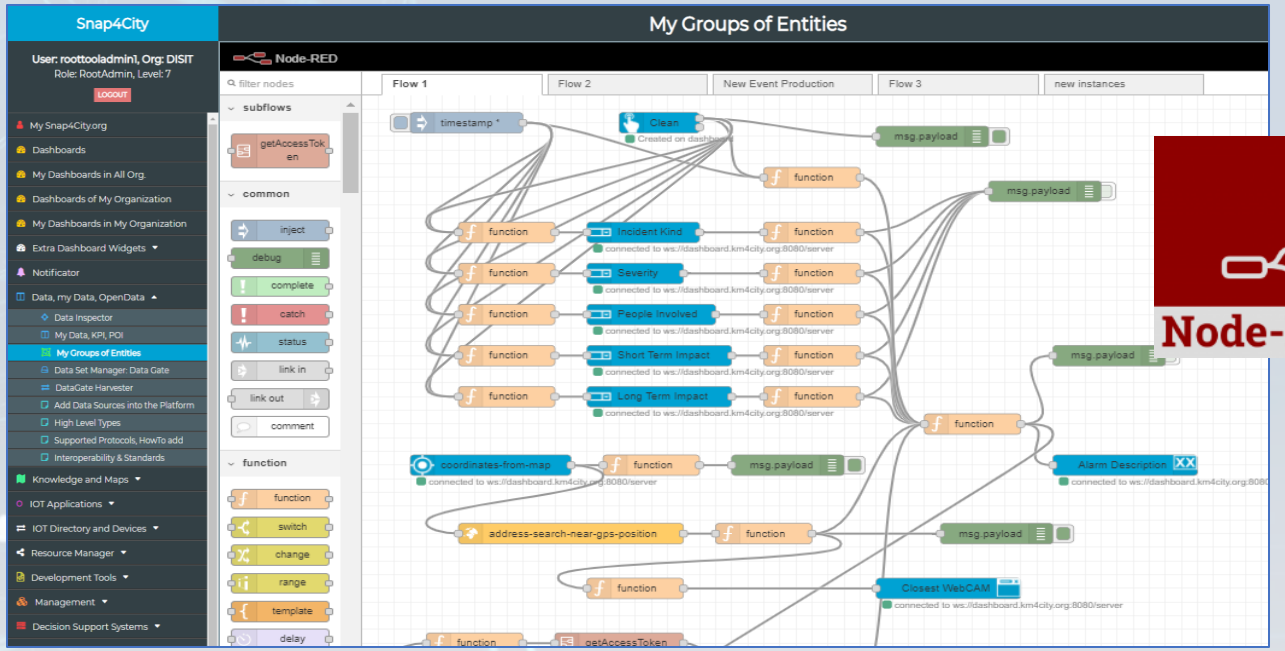


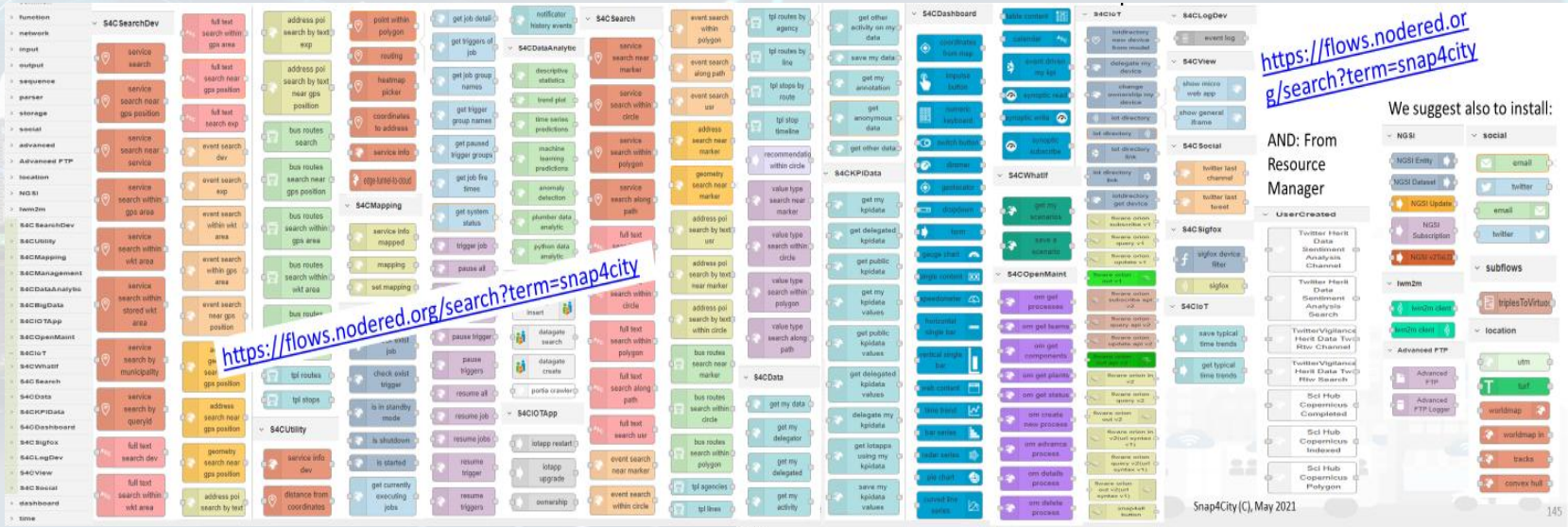
Batch Processing

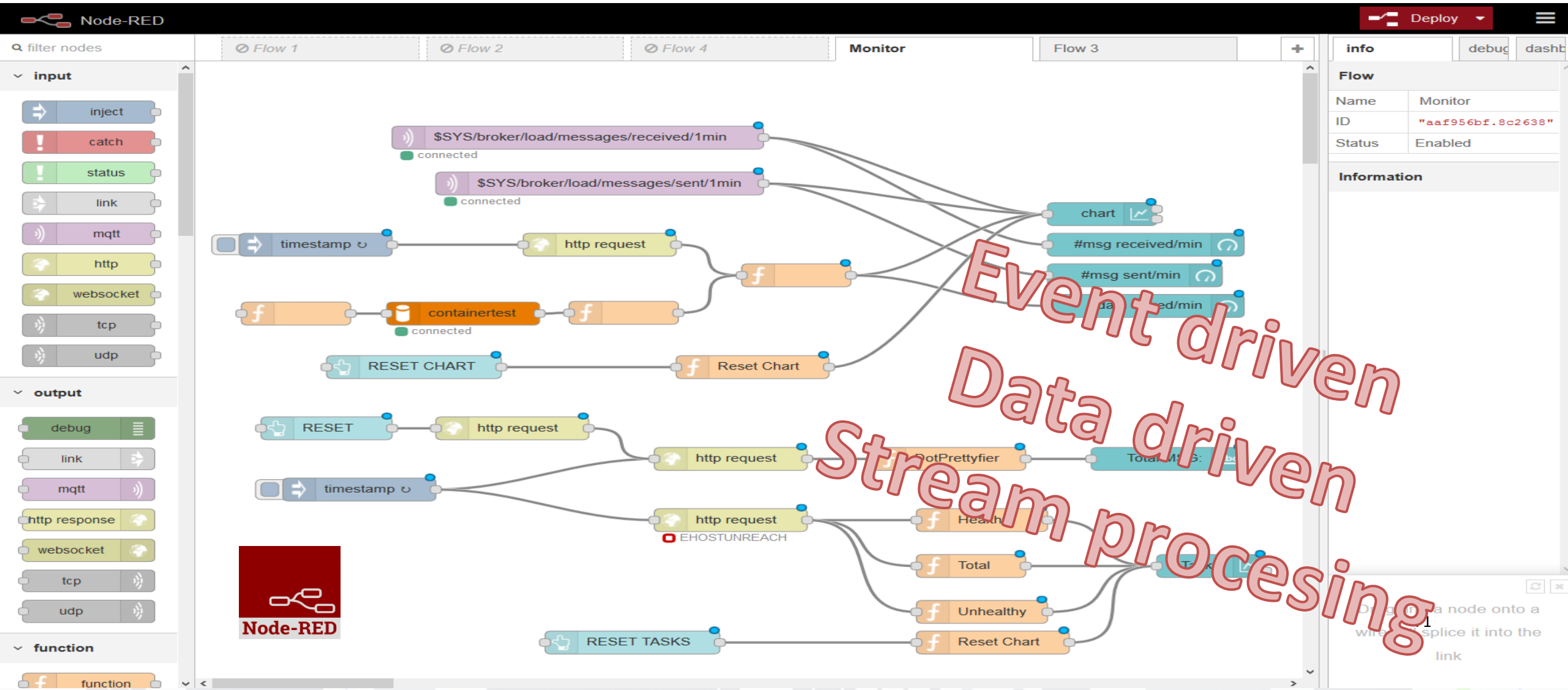
ETL Penthao Kettle

Ingestion, aggreg. → exploitation

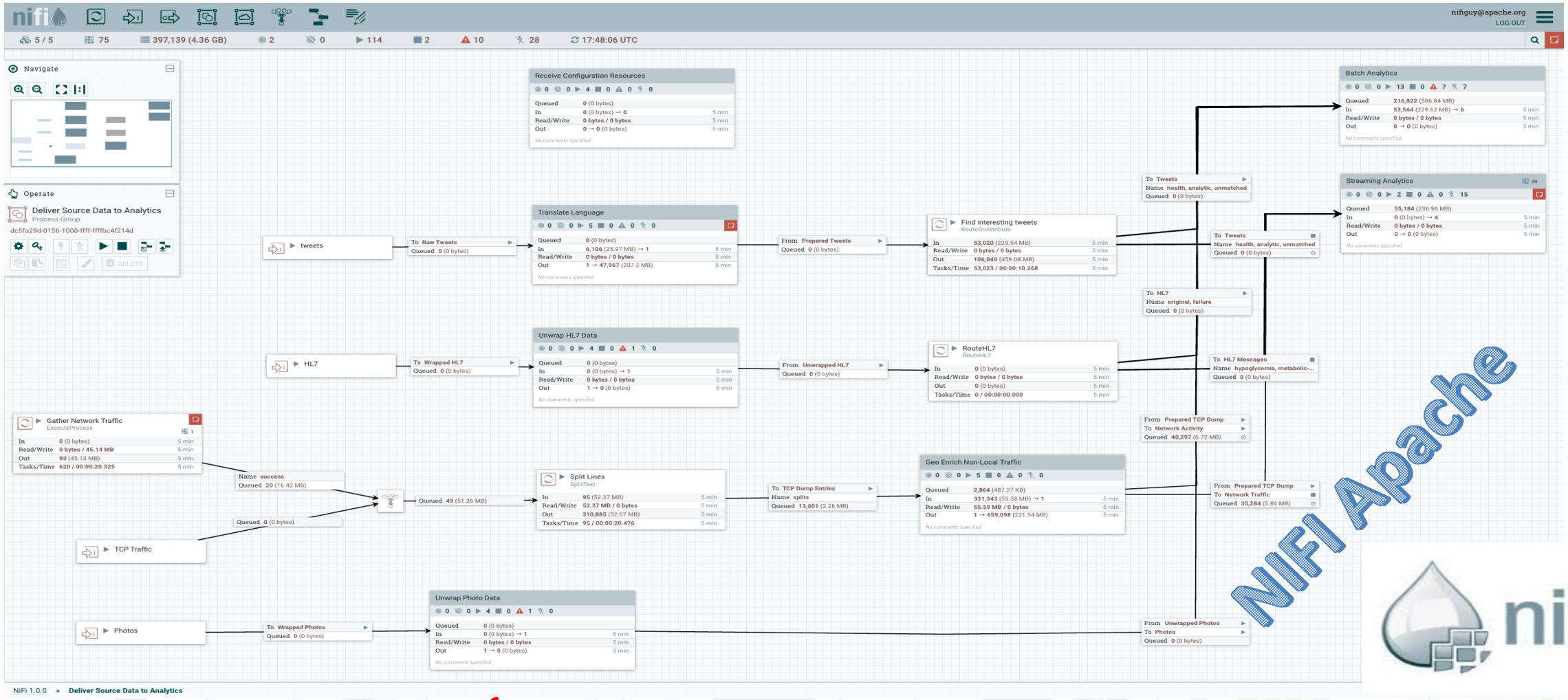
- **IoT App Visual Programming, no coding**
  - Data transformation
  - Integration, Interoperab.
  - Scripting Data Analytics
  - Data ingestion
  - Business logic
- **Edge and Cloud**
- **MicroServices** data driven develop via visual language Node-RED






Node-RED
Deploy
Flow 1
Flow 2
Flow 4
Monitor
Flow 3
info
debug
dashb
Flow
Name
Monitor
ID
"aaf956bf.8c2638"
Status
Enabled
Information
input
inject
catch
status
link
mqtt
http
websocket
tcp
udp
output
debug
link
mqtt
http response
websocket
tcp
udp
function
function
$SYS/broker/load/messages/received/1min
connected
$SYS/broker/load/messages/sent/1min
connected
timestamp
http request
containertest
connected
RESET CHART
Reset Chart
chart
#msg received/min
#msg sent/min
RESET
http request
timestamp
http request
EHOSTUNREACH
DotPrettyfier
Total
Unhealthy
RESET TASKS
Reset Chart
Node-RED
Event driven
Data driven
Stream procesing

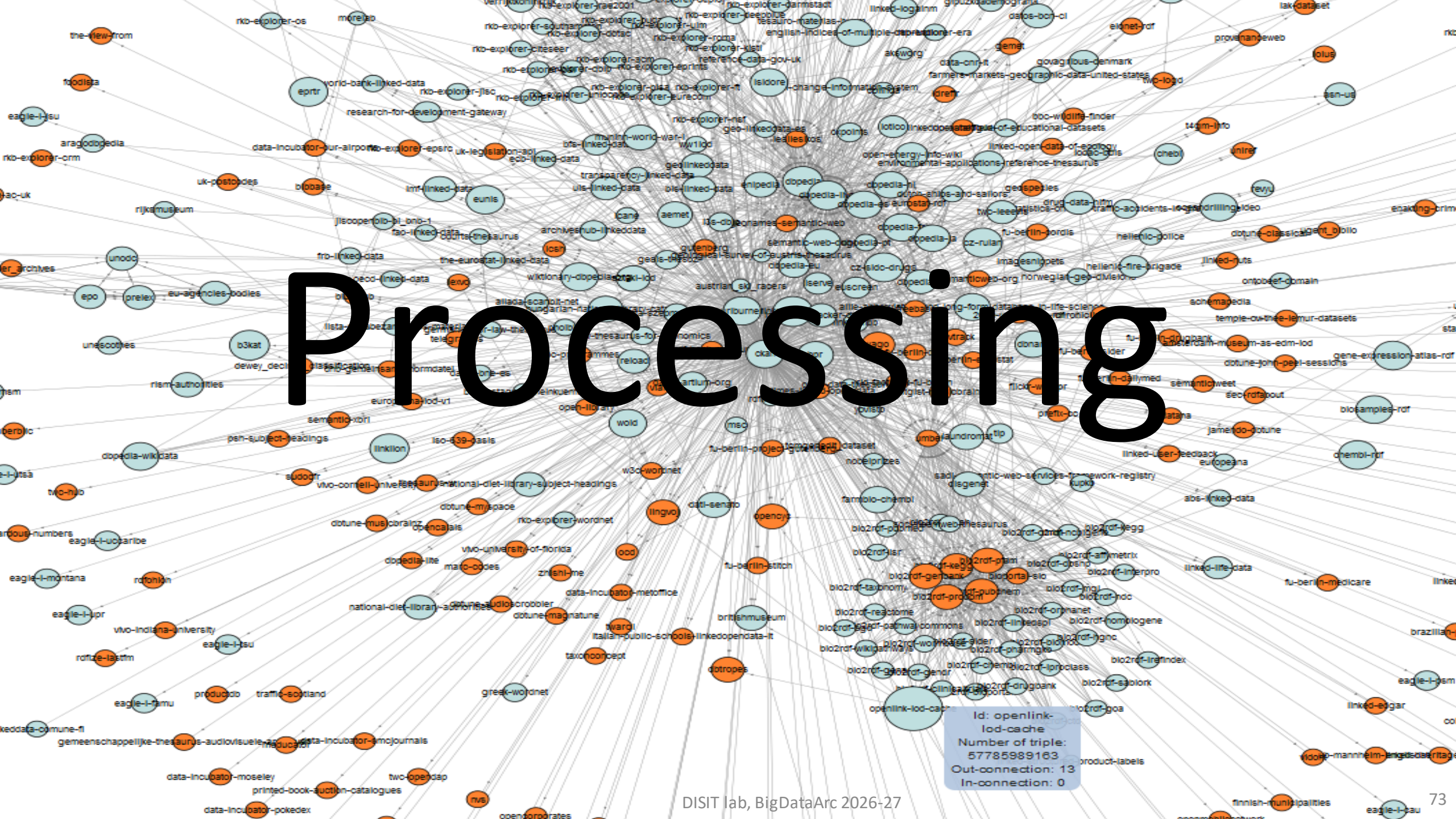
Example of NIFI



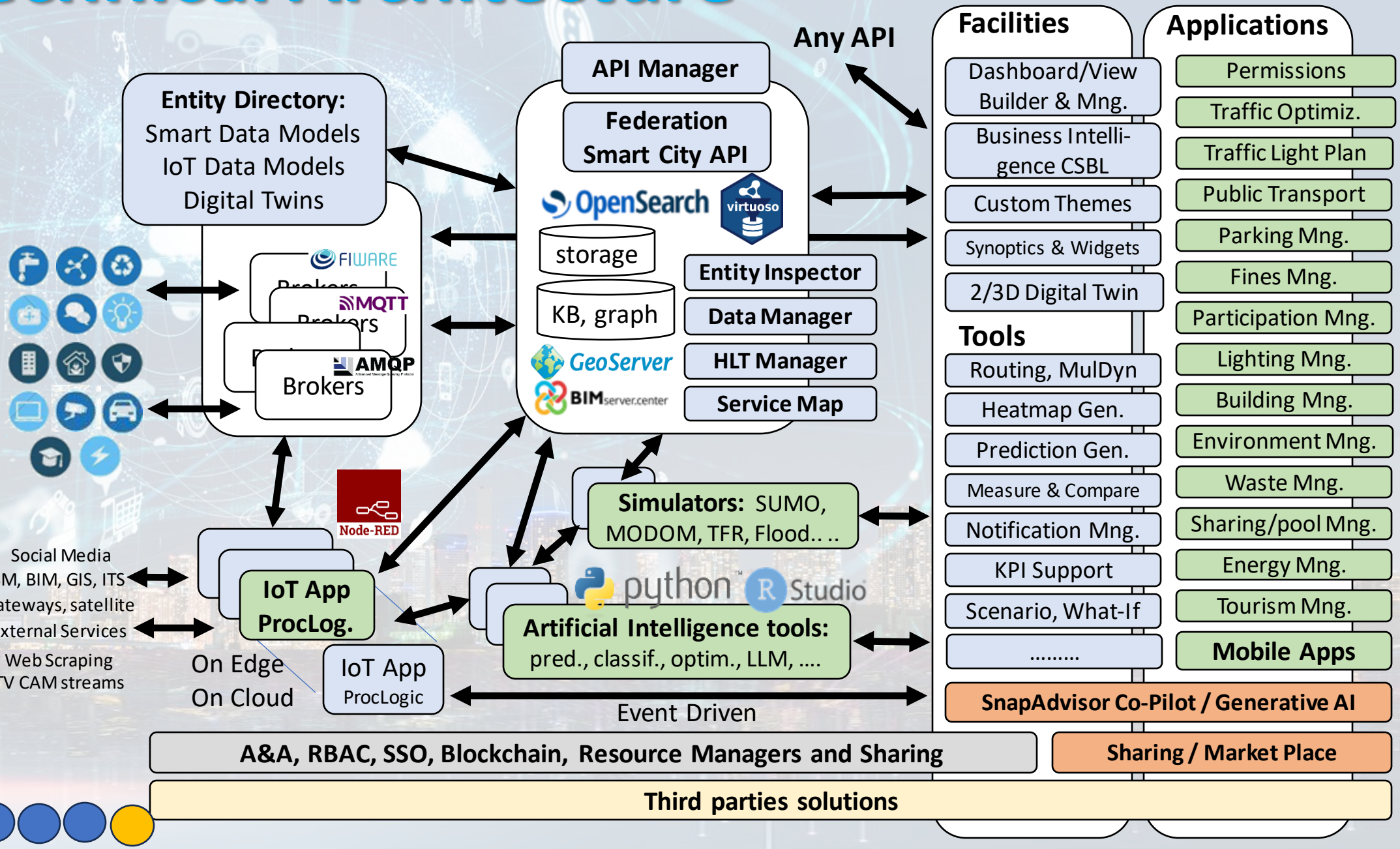
NIFI Apache

nifi

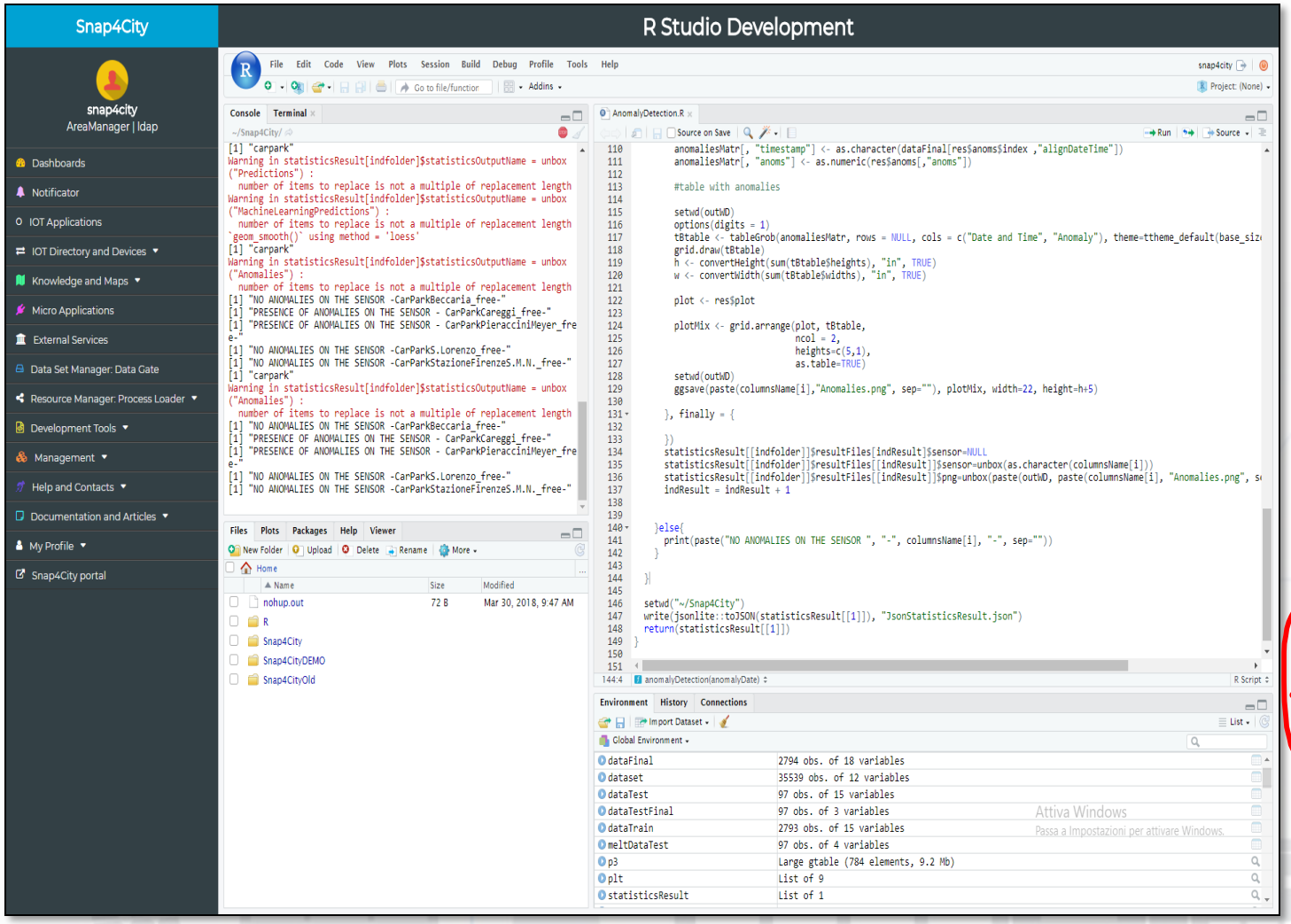
Batch Processing

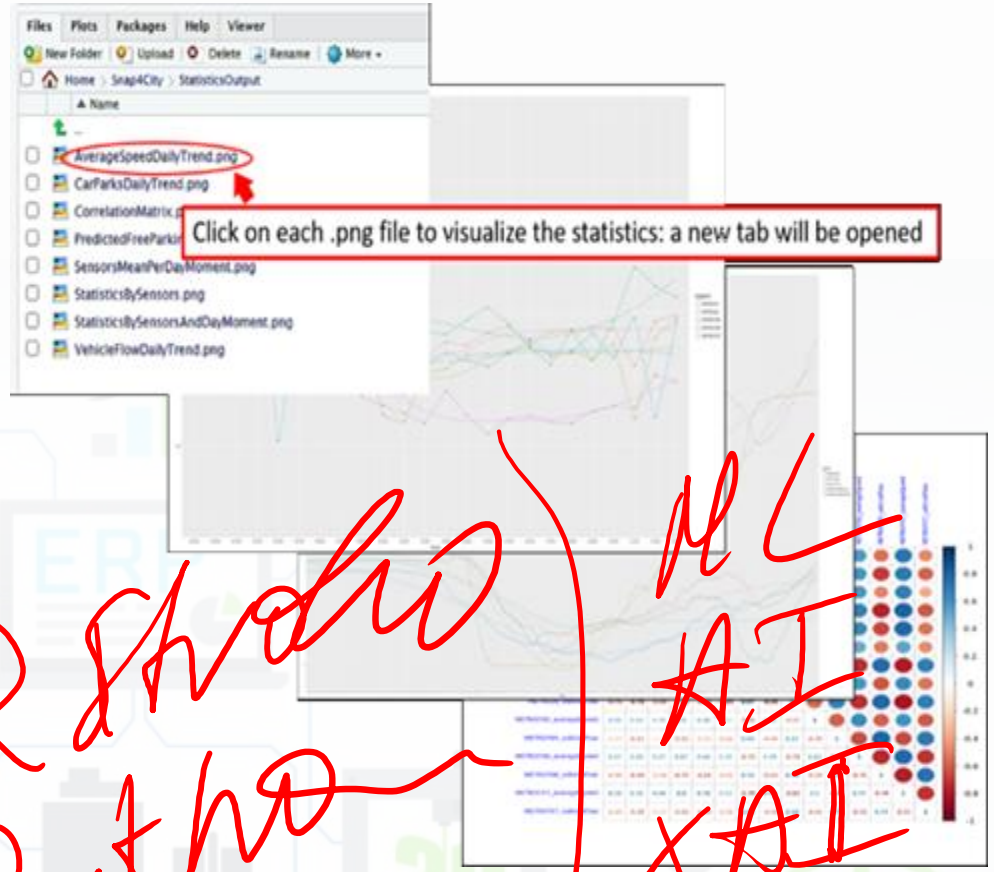

Processing
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

Technical Architecture



Developer in R Studio, Python + Tensor Flow — NVIDIA





R studio
Python
Java
ML
AI
XAI

AI/ML Infrastruct.

SNAP4CITY KM4CITY

SNAP4CITY
DEVELOPMENT
python jupyter RStudio
API
Snap4City API
API
EXECUTION
Node-RED
IOT Application
API
API
API
CLEAR|ML
NVIDIA CUDA
NVIDIA CUDA
NVIDIA CUDA
CPU
HPC
API
Servers
S4CDataAnalytic
plumber data analytic
python data analytic
docker
On Server or On PC
On PC as Local Environment
DEVELOPMENT
NVIDIA CUDA
Any API
A
B
C
NVIDIA CUDA
API
Server Execution
once finalized
Process: file .R or .Py (+ the AI/ML model, data) can be put in execution with local scheduler or Cron

Managing AI/ML operation/development: MLOps

- **Management of AI/ML processes**: training and execution
- **Training needs**: several processes
  - with different parameters and models to be trained, validated and test in batch to find the best results wrt metrics
  - High computational costs, time consuming if the processes have to be sent on GPU/CPU manually
- **Execution needs**, single executions in most cases singularly cheaper, but expensive for large volume of executions:
  - periodically as predictions (saving time if the model is loaded permanent)
  - on demand as optimisation, clustering, etc. (loading model, burning time)

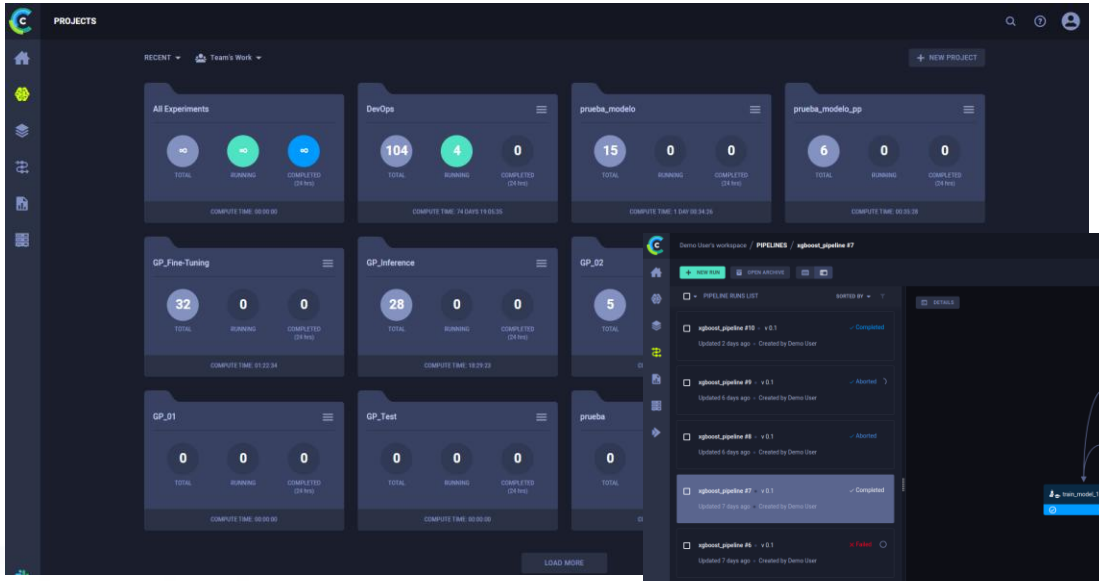
UNIVERSITÀ DEGLI STUDI FIRENZE

DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB
DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB

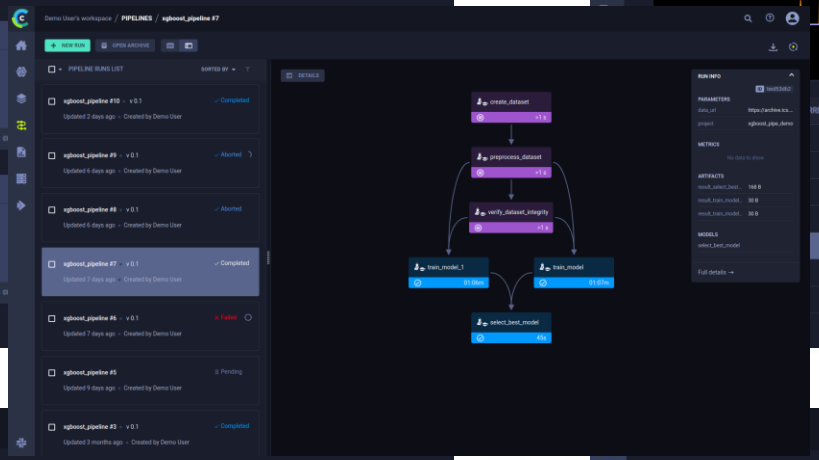
ClearML on S4C

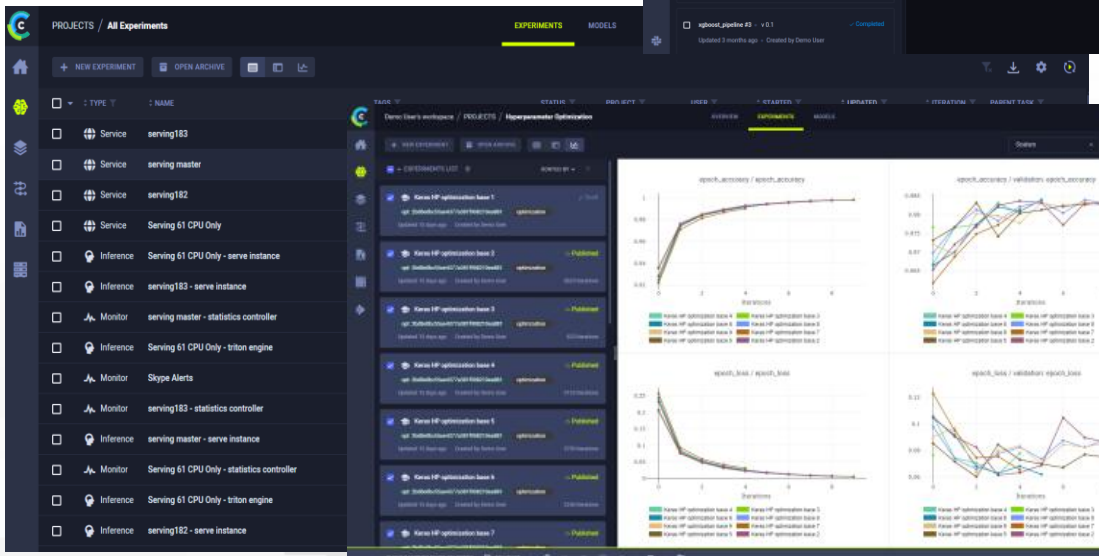
SNAP4CITY KM4CITY

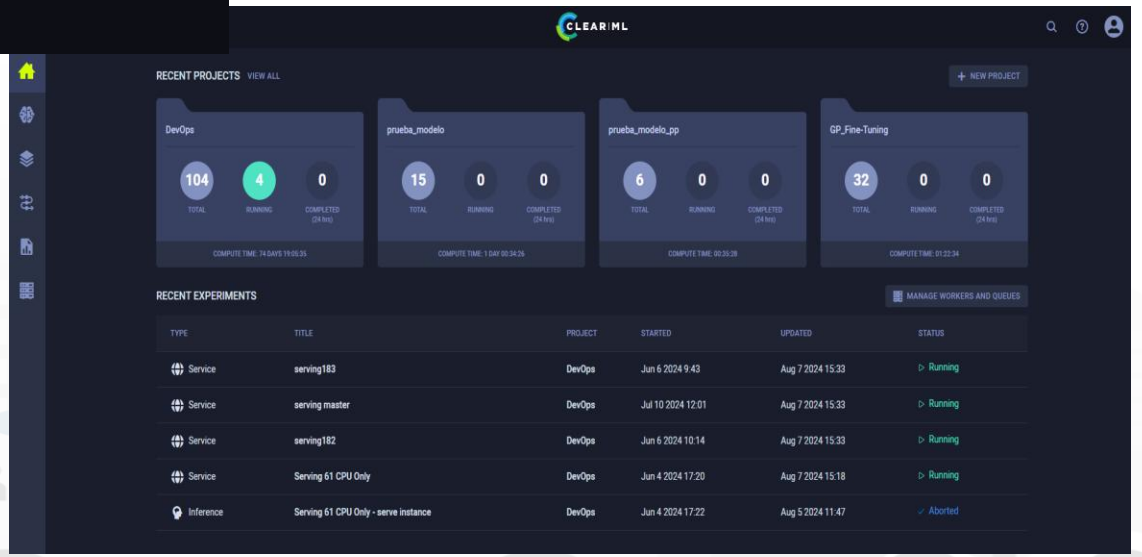


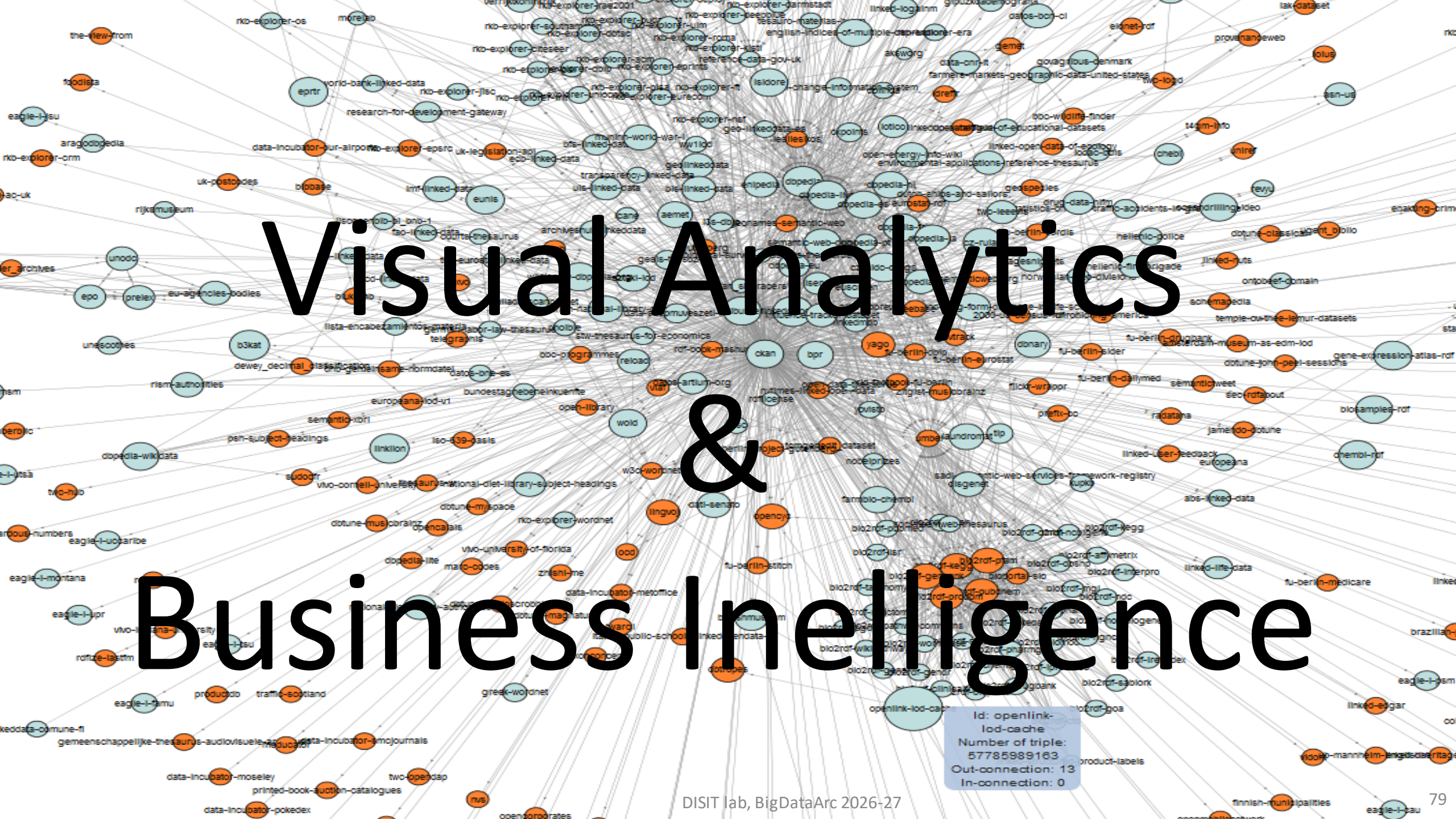


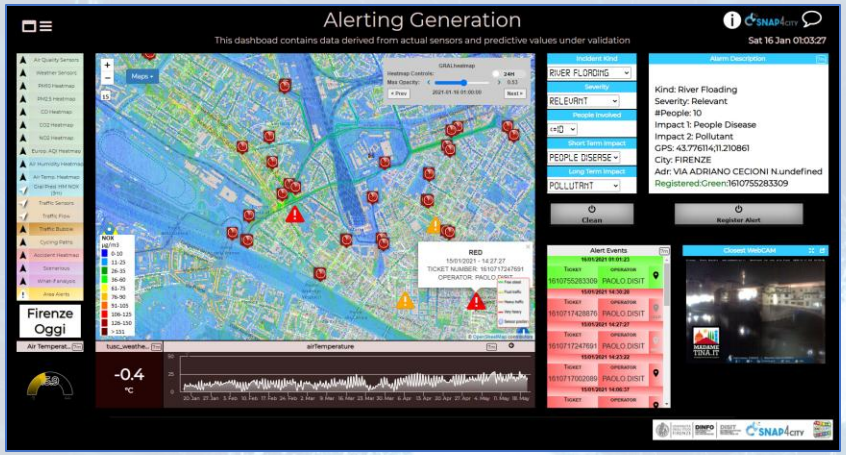
CLEAR|ML

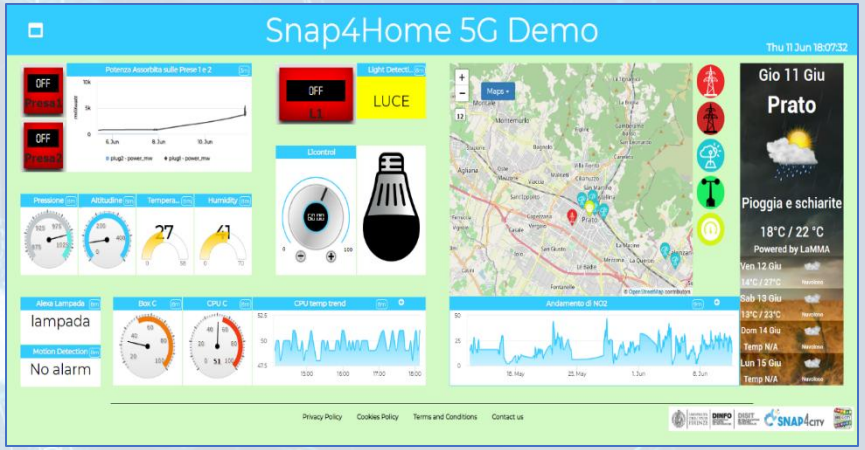


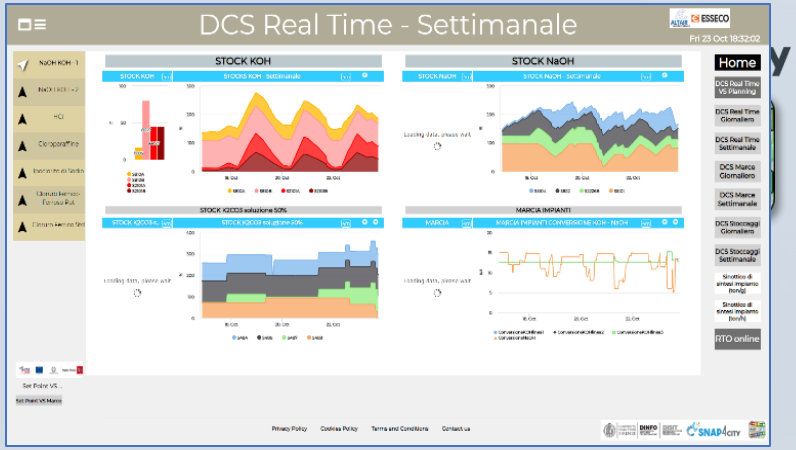


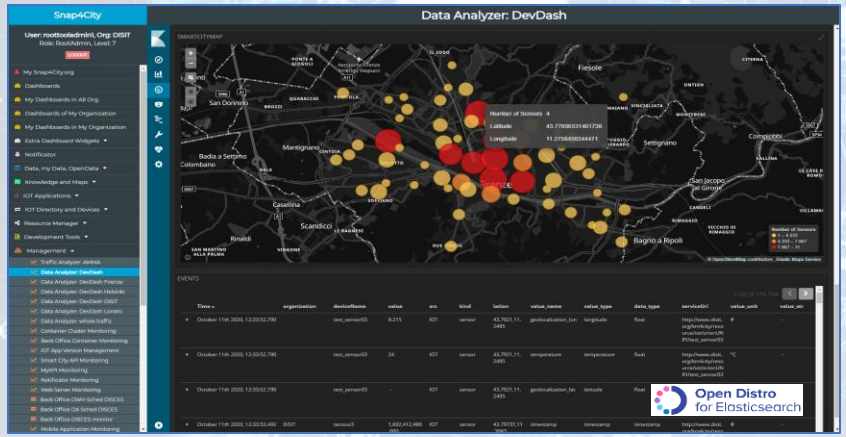


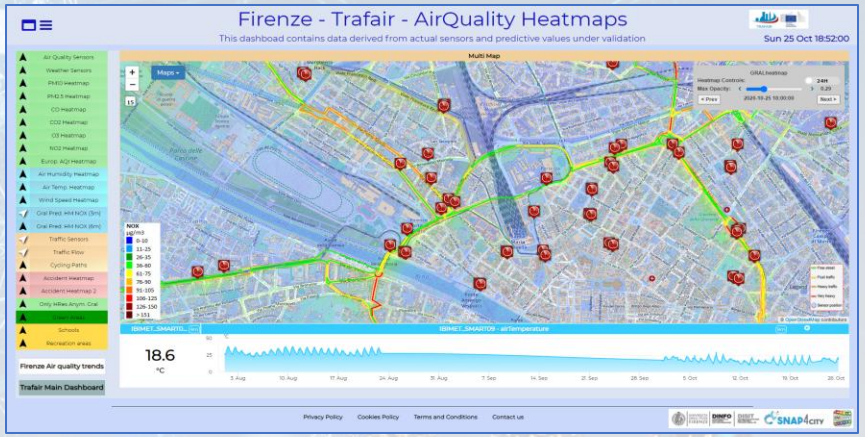

Visual Analytics
&
Business Inelligence
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

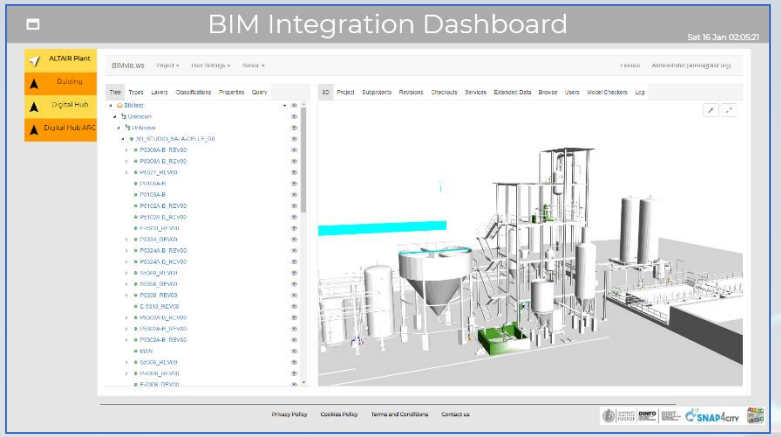

Alerting Generation
This dashboad contains data derived from actual sensors and predictive values under validation
Sat 16 Jan 01:03:27
Firenze Oggi
-0.4


Snap4Home 5G Demo
Thu 11 Jun 18:07:32
LUCE
lampada
No alarm
Gio 11 Giu
Prato
Pioggia e schiarite
18°C / 22 °C
Powered by LaMMA

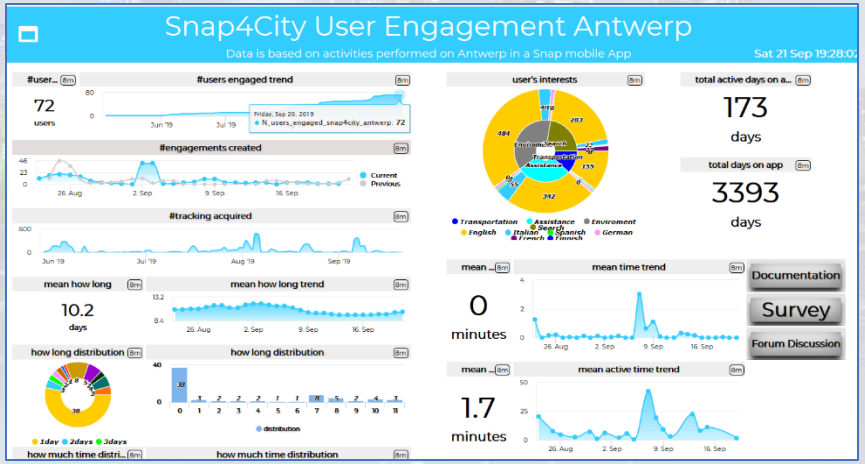

DCS Real Time - Settimanale
Fri 23 Oct 18:32:02
STOCK KOH
STOCK NaOH
Home

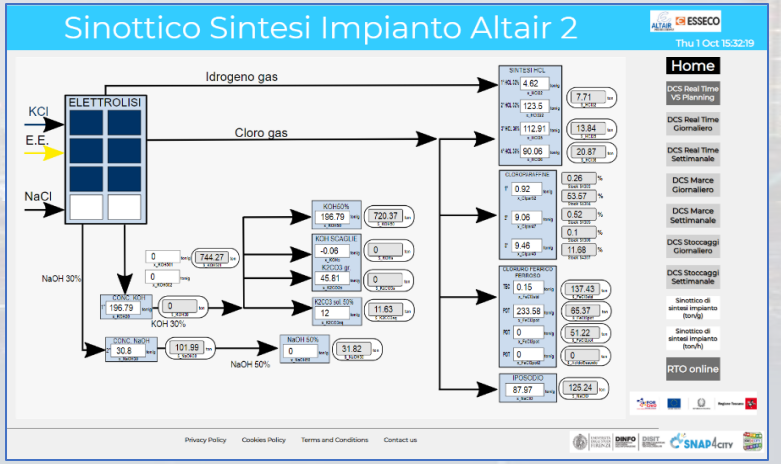

Data Analyzer: DevDash
Open Distro for Elasticsearch

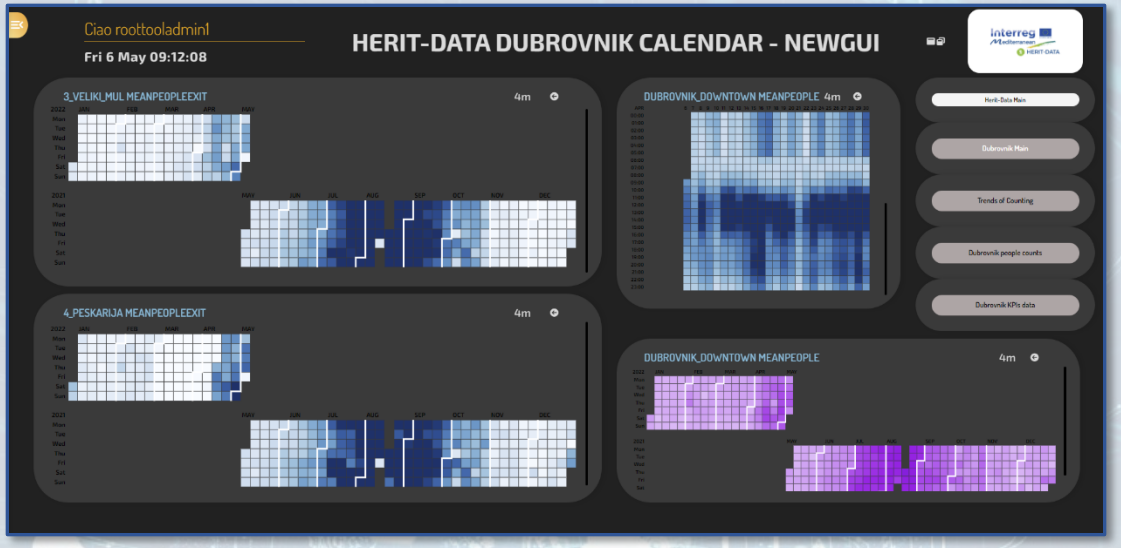

Firenze - Trafair - AirQuality Heatmaps
This dashboad contains data derived from actual sensors and predictive values under validation
Sun 25 Oct 18:52:00
18.6

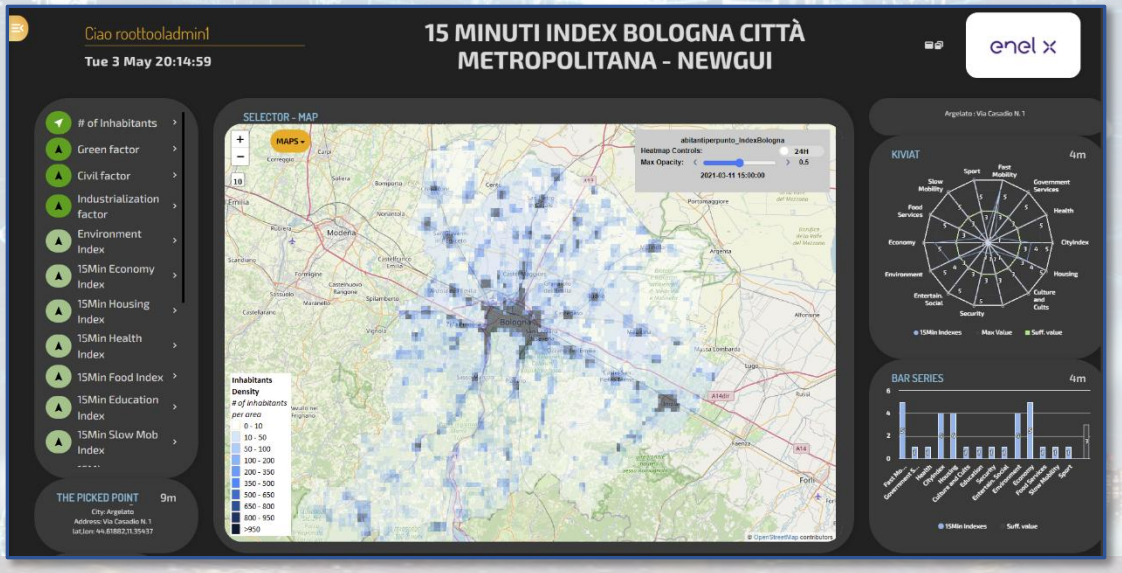

BIM Integration Dashboard
Sat 16 Jan 02:05:21

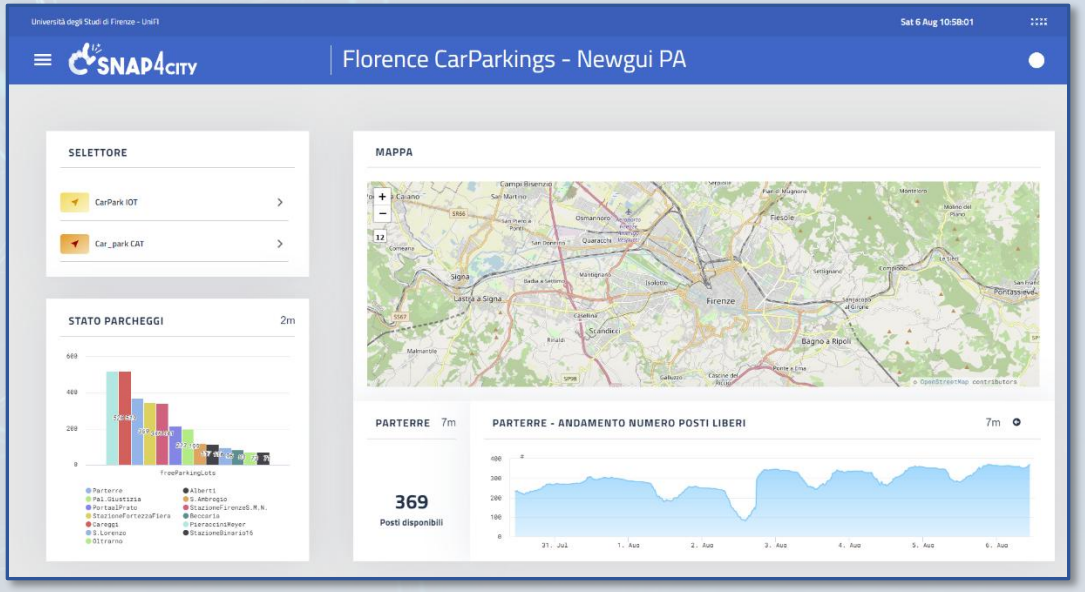

3D Multi Data Map - Digital Twin Global - Firenze
demonstrator
Sun 3 Apr 16:03:52
192

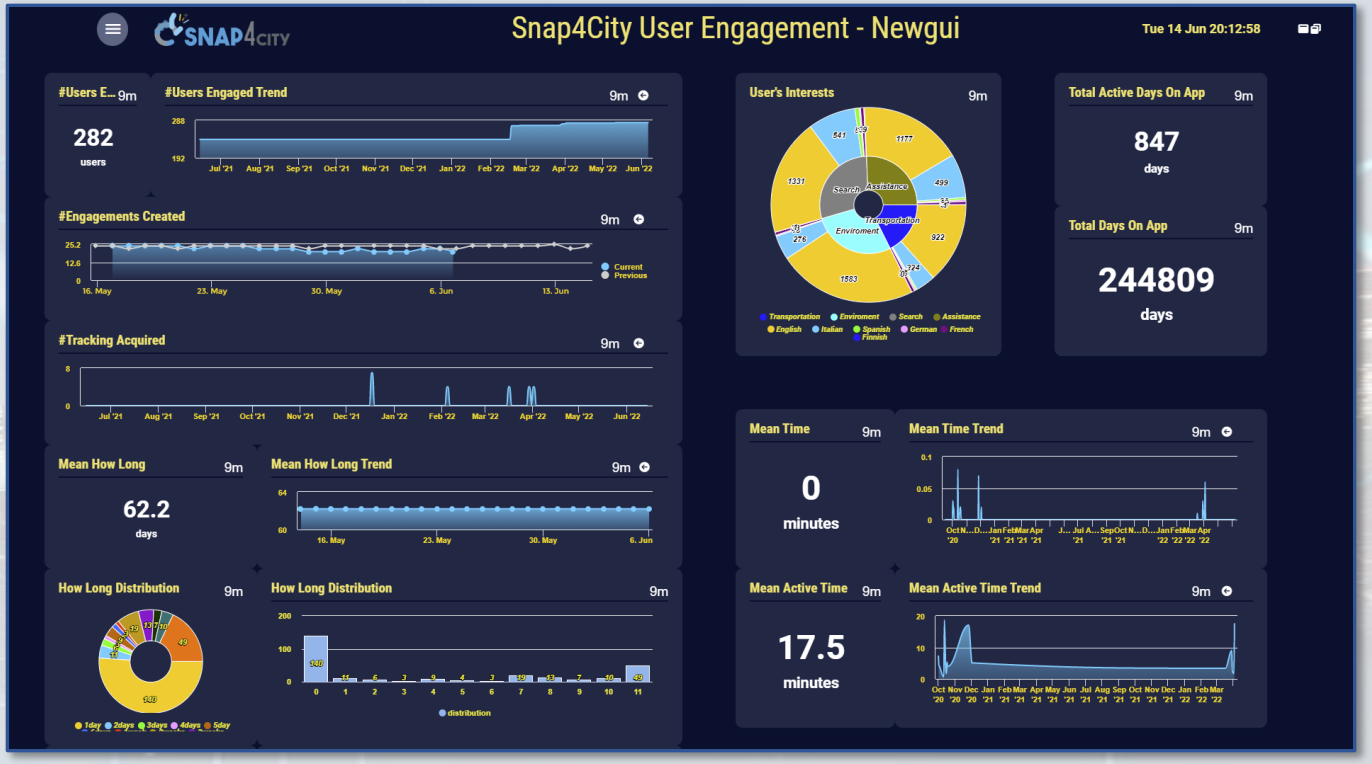

Snap4City User Engagement Antwerp
Data is based on activities performed on Antwerp in a Snap mobile App
Sat 21 Sep 19:28:07
72
users
173
days
3393
days
0
minutes
1.7
minutes
Documentation
Survey
Forum Discussion


Sinottico Sintesi Impianto Altair 2
Thu 1 Oct 15:32:19
Home
Idrogeno gas
Cloro gas
ELETTROLISI
KCl
E.E.
NaCl
NaOH 30%
KOH 30%
NaOH 50%





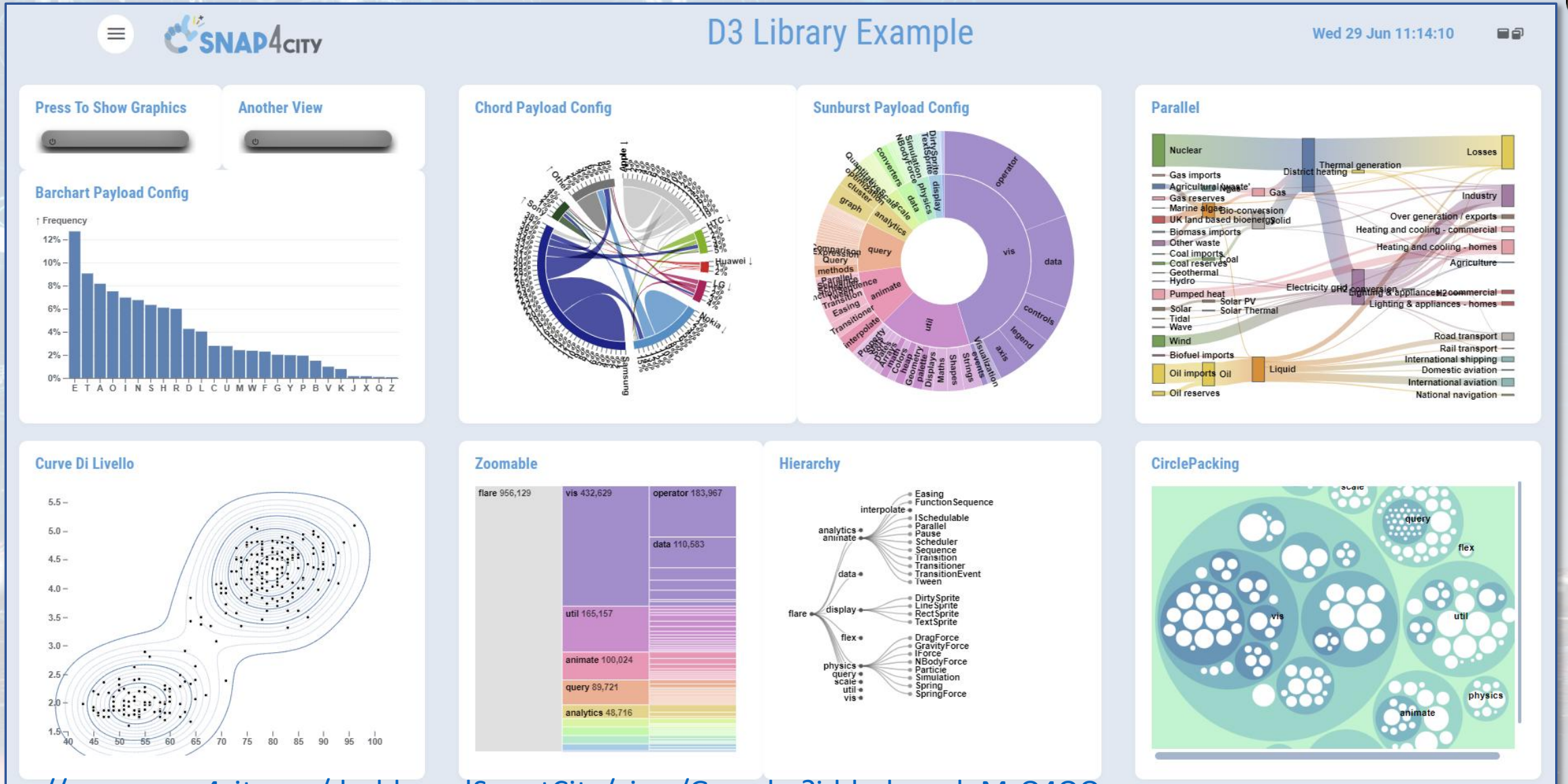




New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

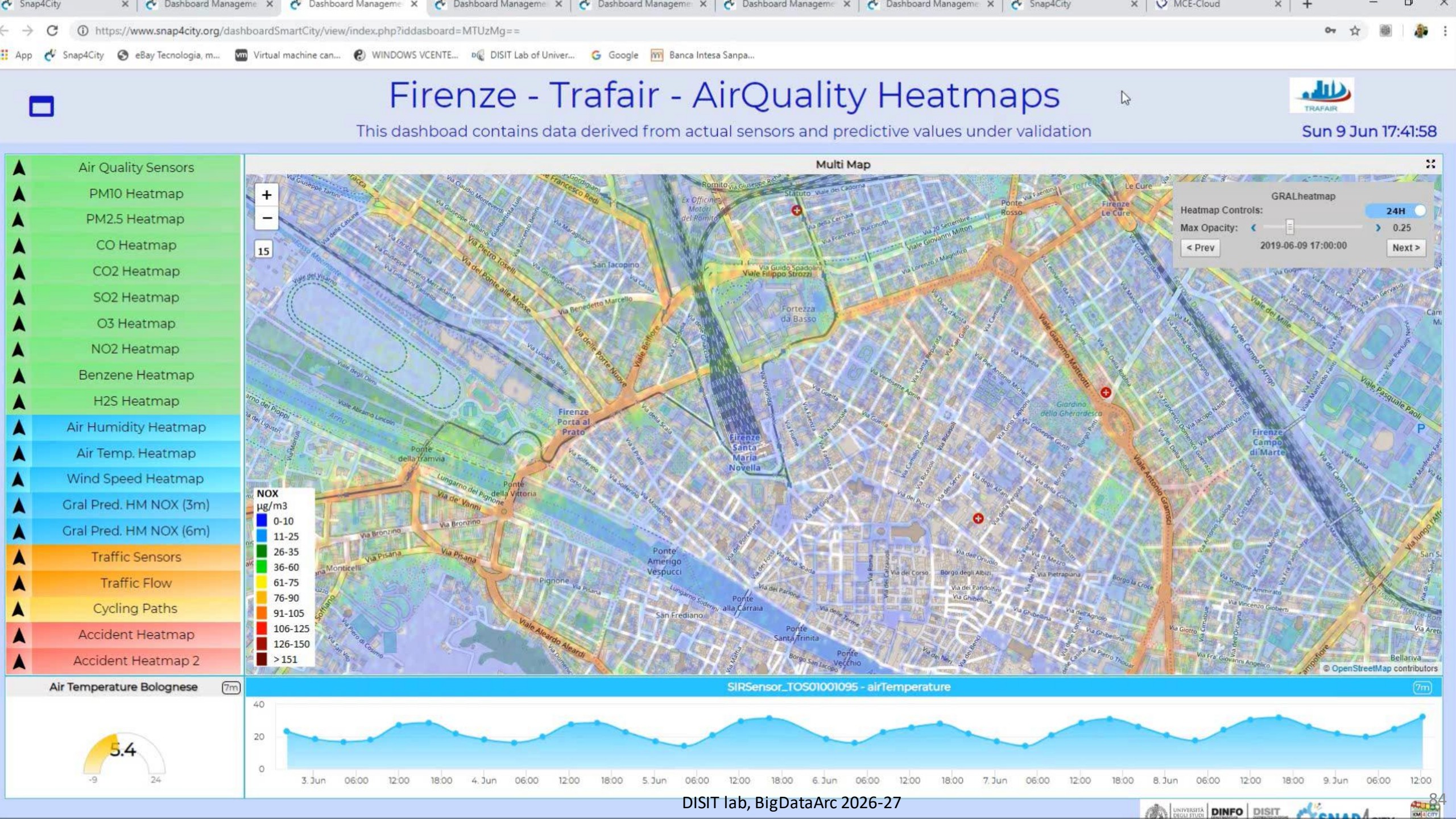
D3 Graph library capability



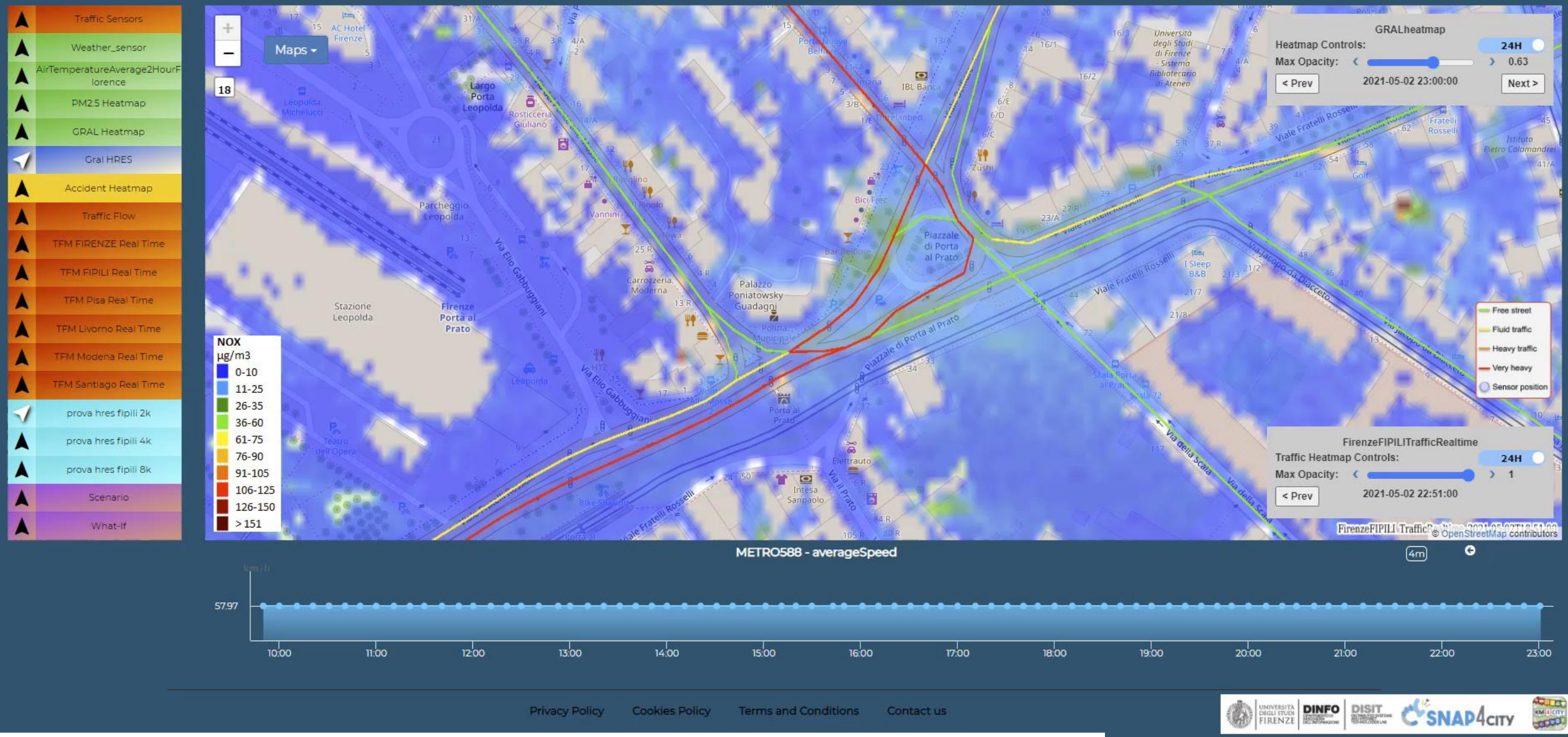
https://www.snap4city.org/dashboardSmartCity/view/Gea.php?iddasboard=MzQ4OQ==



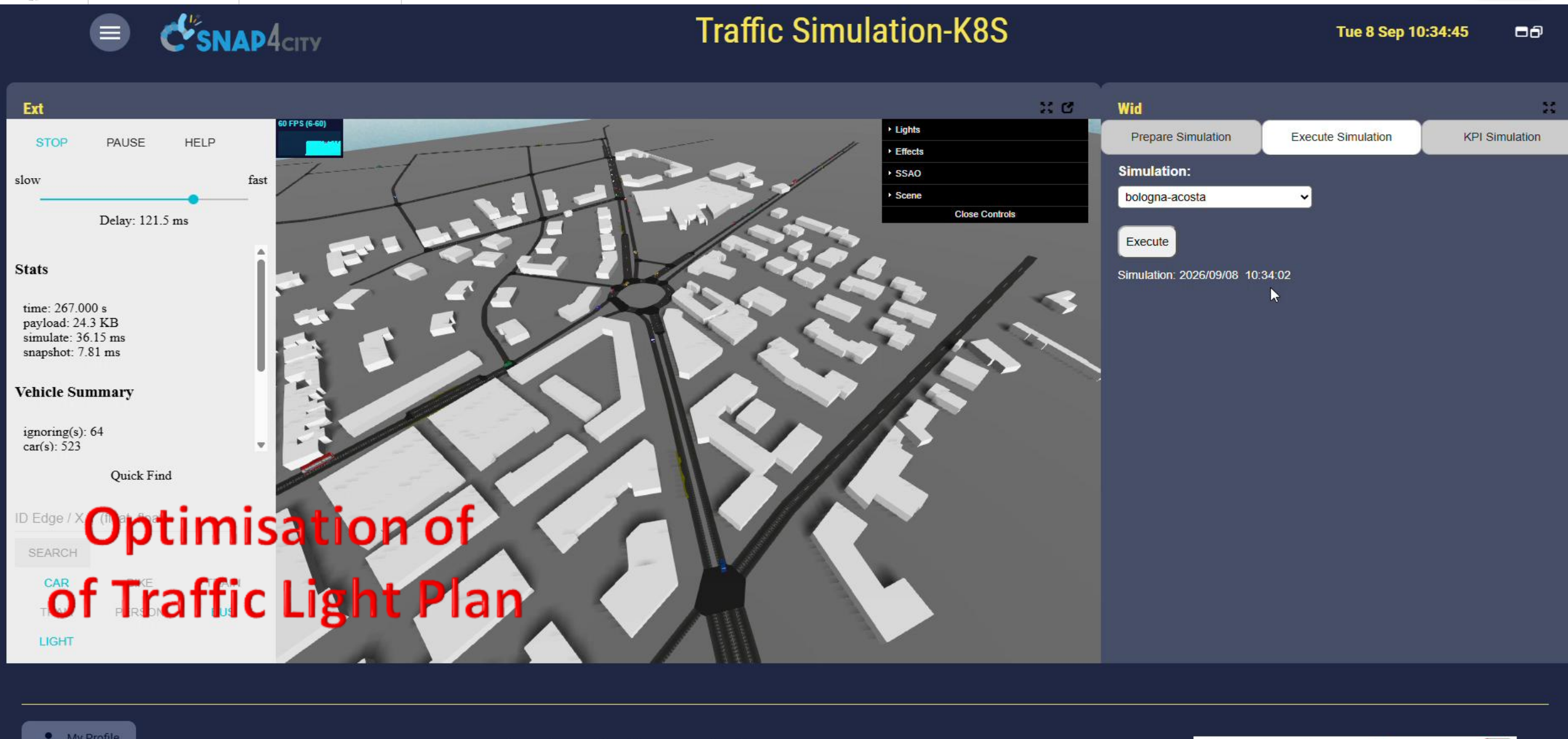
http://www.darionardella.it/il-sindaco-dario-nardella-in-missione-a-madrid-e-barcellona/


Firenze - Trafair - AirQuality Heatmaps
This dashboad contains data derived from actual sensors and predictive values under validation
Sun 9 Jun 17:41:58
Air Quality Sensors
PM10 Heatmap
PM2.5 Heatmap
CO Heatmap
CO2 Heatmap
SO2 Heatmap
O3 Heatmap
NO2 Heatmap
Benzene Heatmap
H2S Heatmap
Air Humidity Heatmap
Air Temp. Heatmap
Wind Speed Heatmap
Gral Pred. HM NOX (3m)
Gral Pred. HM NOX (6m)
Traffic Sensors
Traffic Flow
Cycling Paths
Accident Heatmap
Accident Heatmap 2
Multi Map
GRALheatmap
Heatmap Controls:
24H
Max Opacity:
0.25
< Prev
2019-06-09 17:00:00
Next >
NOX
µg/m3
0-10
11-25
26-35
36-60
61-75
76-90
91-105
106-125
126-150
>151
© OpenStreetMap contributors
Air Temperature Bolognese
7m
5.4
-9
24
SIRSensor_TOS01001095 - airTemperature
7m
40
20
0
3. Jun
4. Jun
5. Jun
6. Jun
7. Jun
8. Jun
9. Jun

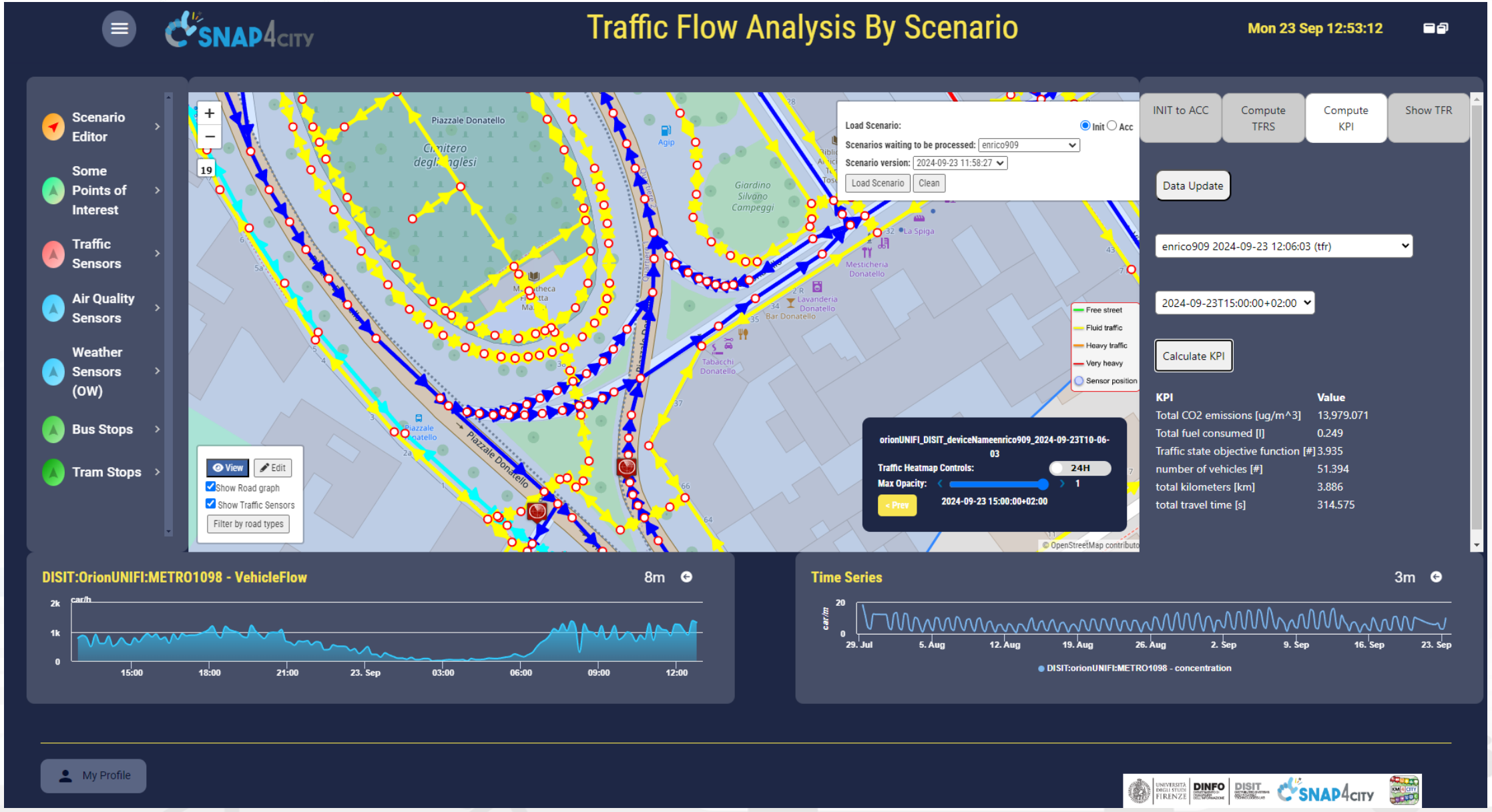
Traffic Flow Manager on multiple cities



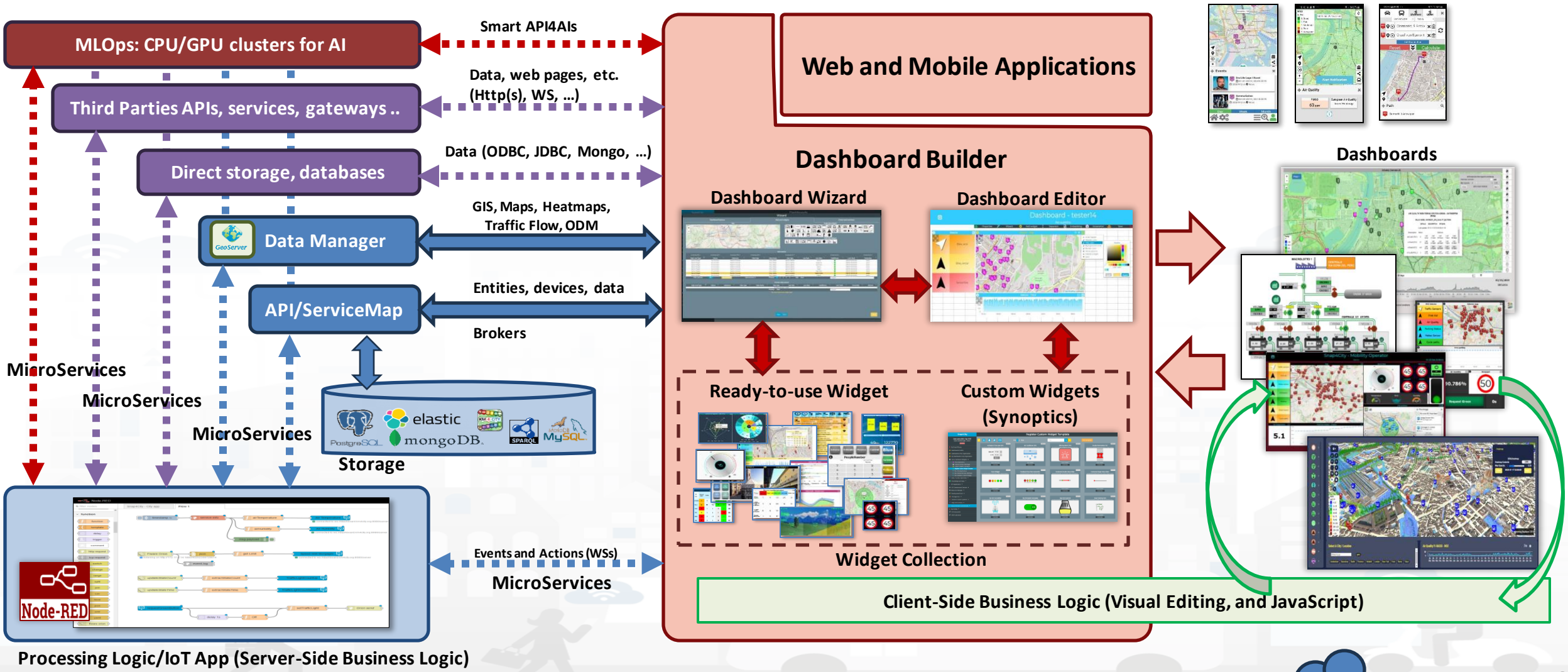
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzEyNg==

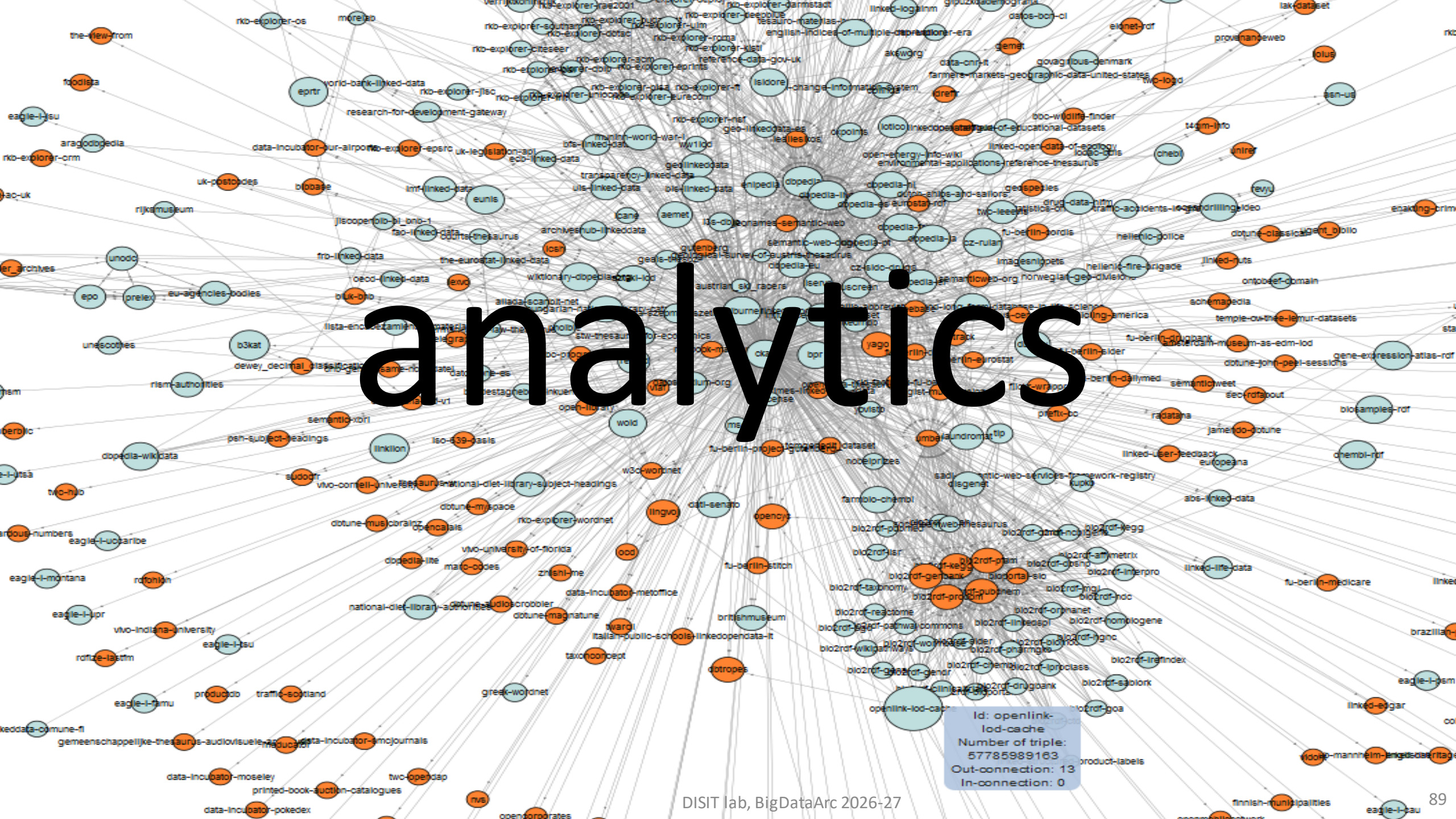

Traffic Simulation-K8S
Tue 8 Sep 10:34:45
Ext
STOP
PAUSE
HELP
slow
fast
Delay: 121.5 ms
Stats
time: 267.000 s
payload: 24.3 KB
simulate: 36.15 ms
snapshot: 7.81 ms
Vehicle Summary
ignoring(s): 64
car(s): 523
Quick Find
SEARCH
CAR
LIGHT
60 FPS (6-60)
Lights
Effects
SSAO
Scene
Close Controls
Wid
Prepare Simulation
Execute Simulation
KPI Simulation
Simulation:
bologna-acosta
Execute
Simulation: 2026/09/08 10:34:02
Optimisation of
of Traffic Light Plan
My Profile
Privacy Policy
Cookies Policy
Terms and Conditions
Contact us

What-if on TFR



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




analytics
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

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**

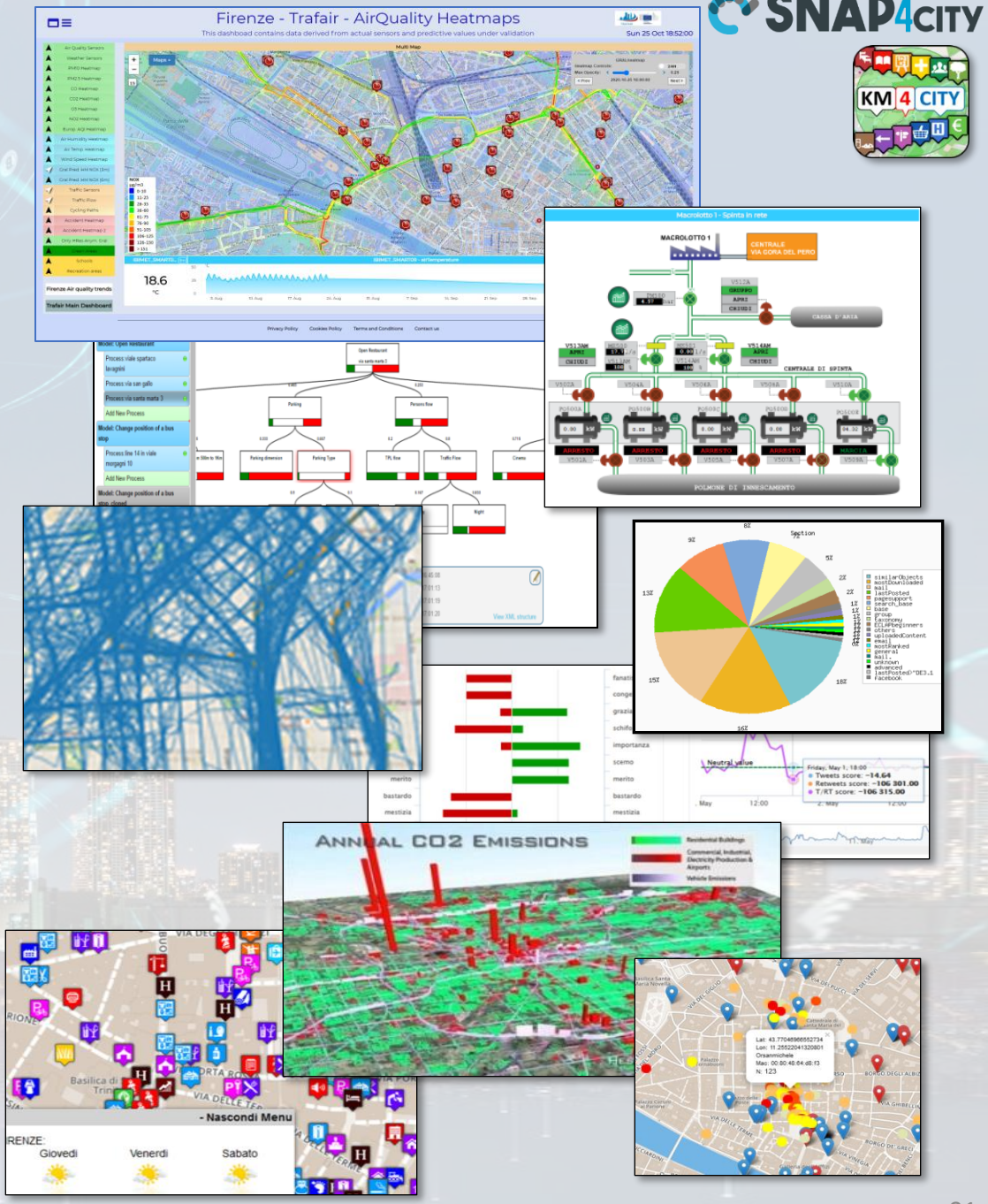


https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

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

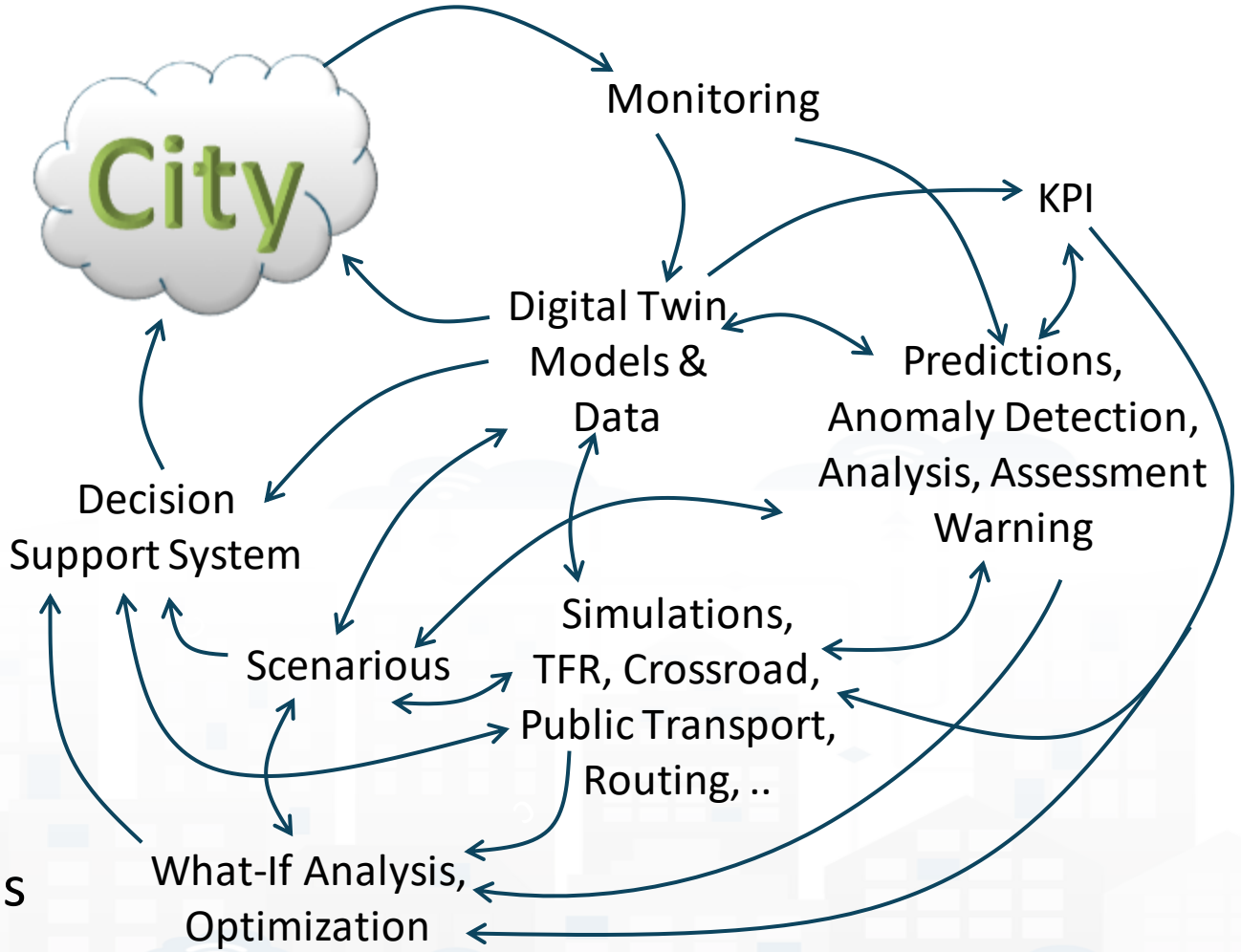
Data Driven Decision Support

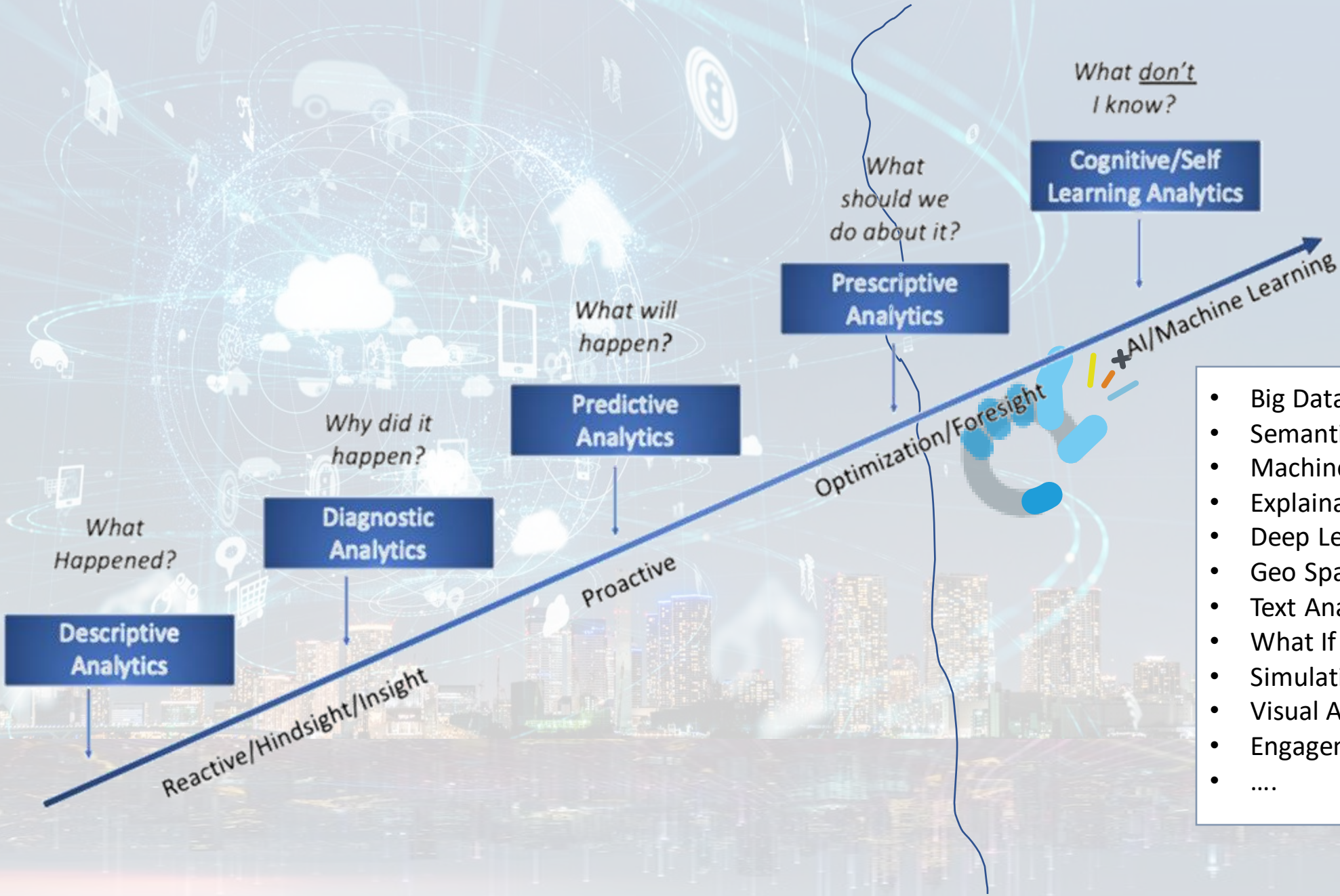
- Decision Support system
- Assessment / Strategies
- Data Rendering, visual analytics
- Data Processing
- Data aggregation, Storage, indexing
- Data Ingestion



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





Sentient and active processes

- Big Data Analytics
- Semantic Computing
- Machine Learning
- Explainable Artificial Intelligence
- Deep Learning
- Geo Spatial Reasoning
- Text Analysis, Sentiment Analysis
- What If Analysis
- Simulations
- Visual Analytics
- Engagement Analysis
- ….

SUSTAINABLE DEVELOPMENT GOALS

SNAP4CITY

KM 4 CITY









- ***15 Minute City Index:***
  - 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security…



- Optimization of car sharing/pooling
- Monitoring and Prediction of energy consumption
- Stimulating: Bike sharing, e-bikes, car charge, etc.
- Sizing energy plants, Community of energy



- Reduction of emissions, reduction of congestions
- Smart City infrastructure: monitoring and resilience, long terms predictions, optim. operation and plan
- Effective and Low cost smart solutions
- What-if analysis, Simulations, optimization
- Origin Destination matrices computation





- Reduction of emissions, reduction of congestions
- Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction, optimisation
- Demand vs Offer of Mobility analysis



- Predictive maintenance
- Decisions Support Systems
- Process optimization, control
- Industry 4.0 integrated solutions
- AI assistant for commercial activities

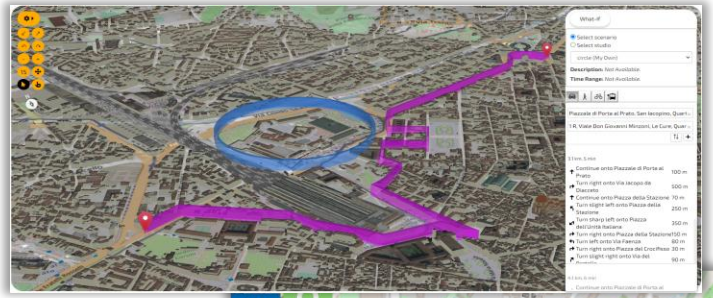


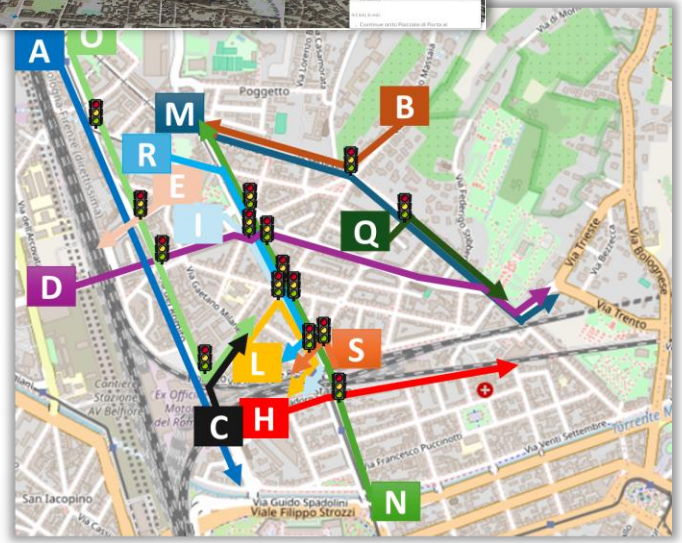
- Optimization of Waste Collection
- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Advisor for documentation, generative AI



- Shortening justice time
- Prediction of mediation proneness
- Assisting institution is taking legal decisions
- Anonymization and indexing legal docs.
- Ethical Explainable Artificial Intelligence
- Advisor for legal documentation, generative AI

Mobility



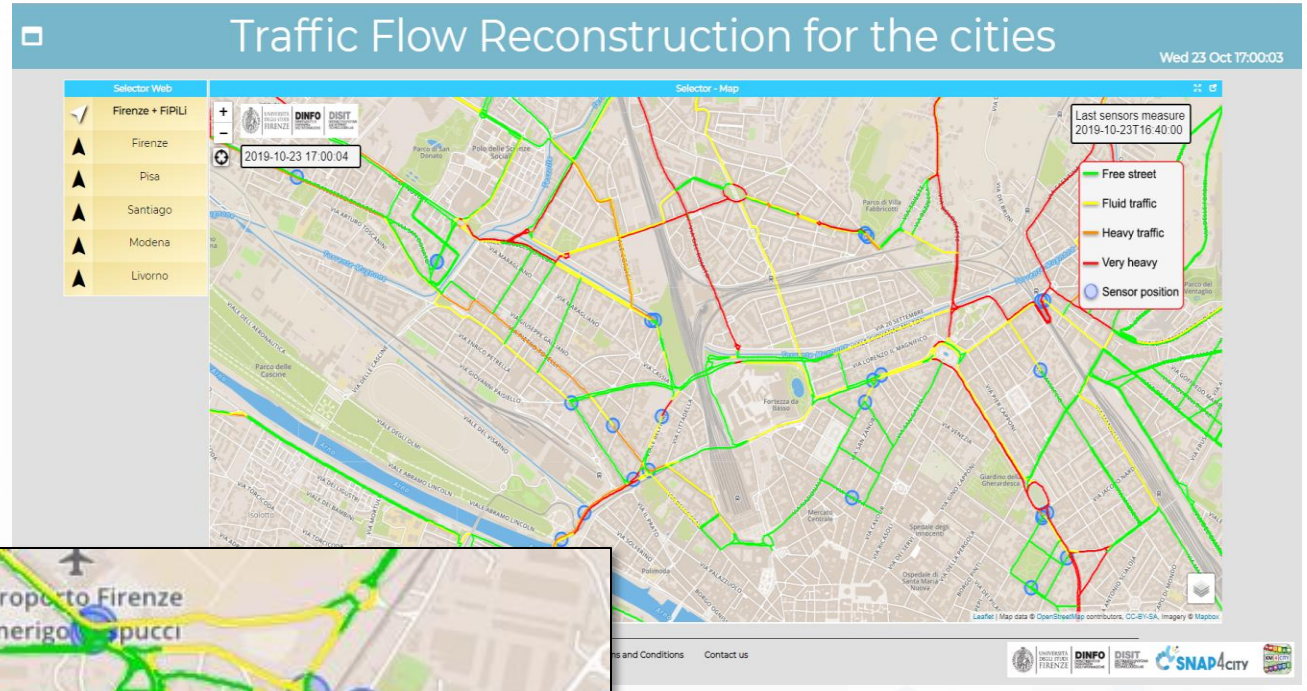




- **Goals:**
  - Decongestion, Decarbonization, costs reductions
  - Improve Accessibility to services
  - Improve Security/Safety of city users
- **Operation and Plan**:
  - Traffic monitoring, prediction, reconstruction, identification of critical conditions (early warning), fleet management, dynamic 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.**

Why Dense Traffic Flow Reconstruction ?

- Making decision on mobility and transport solutions → what if analysis
- Controlling pollution
- Dynamic Routing for Firebrigade, Ambulances, general public
- Planning Public Transportation routing





https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==

Big Data & Analytics

- **Solutions for**
  - **Predicting models**
  - **Early detection**
  - **Anomaly detection**
- **Data Analytics**
  - Data mining, Clustering
  - Semantic computing
  - Machine learning
  - Natural Language Processing, Sentiment Analysis
- **Architetture parallele**
  - Hadoop, Spark, Kafka, map reduce
  - Hdfs, Hbase, Mongo, Virtuoso, RDF stores
  - Distributed Scheduling
  - GPU
- **IOT/IOE**
  - Protocols
  - Devices
  - Data aggregation

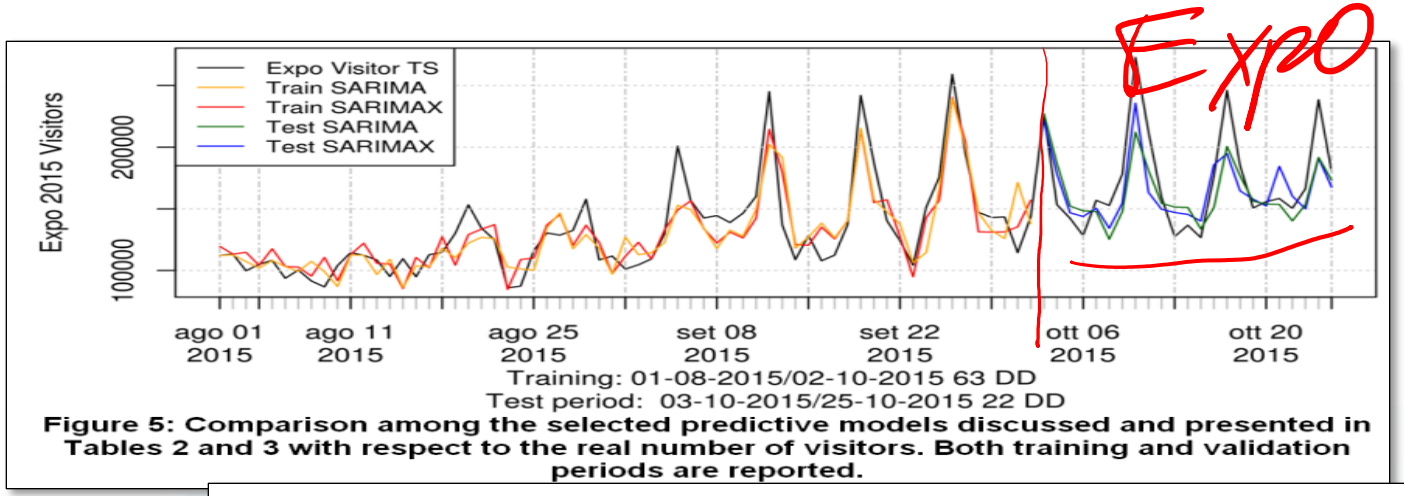
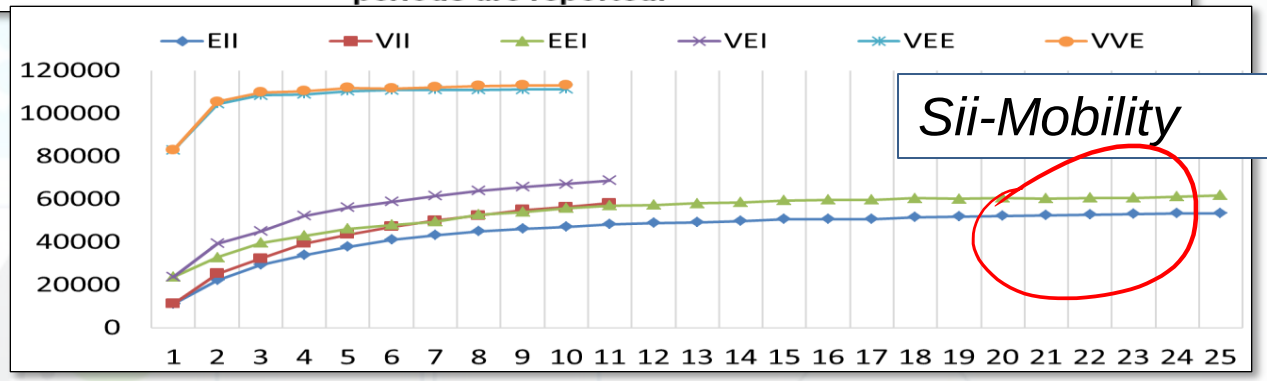
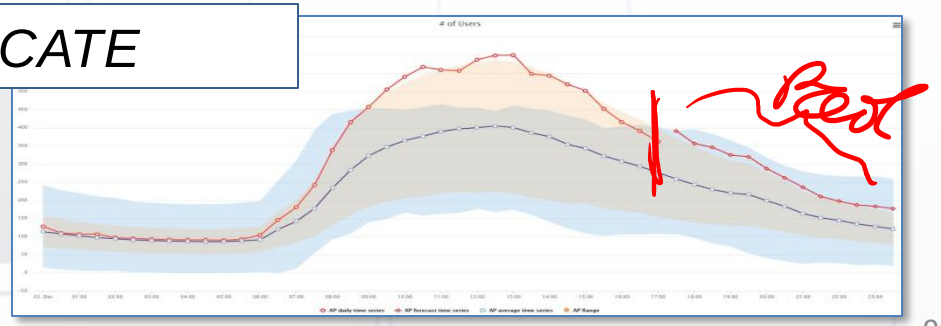


Figure 5: Comparison among the selected predictive models discussed and presented in Tables 2 and 3 with respect to the real number of visitors. Both training and validation periods are reported.



Sii-Mobility

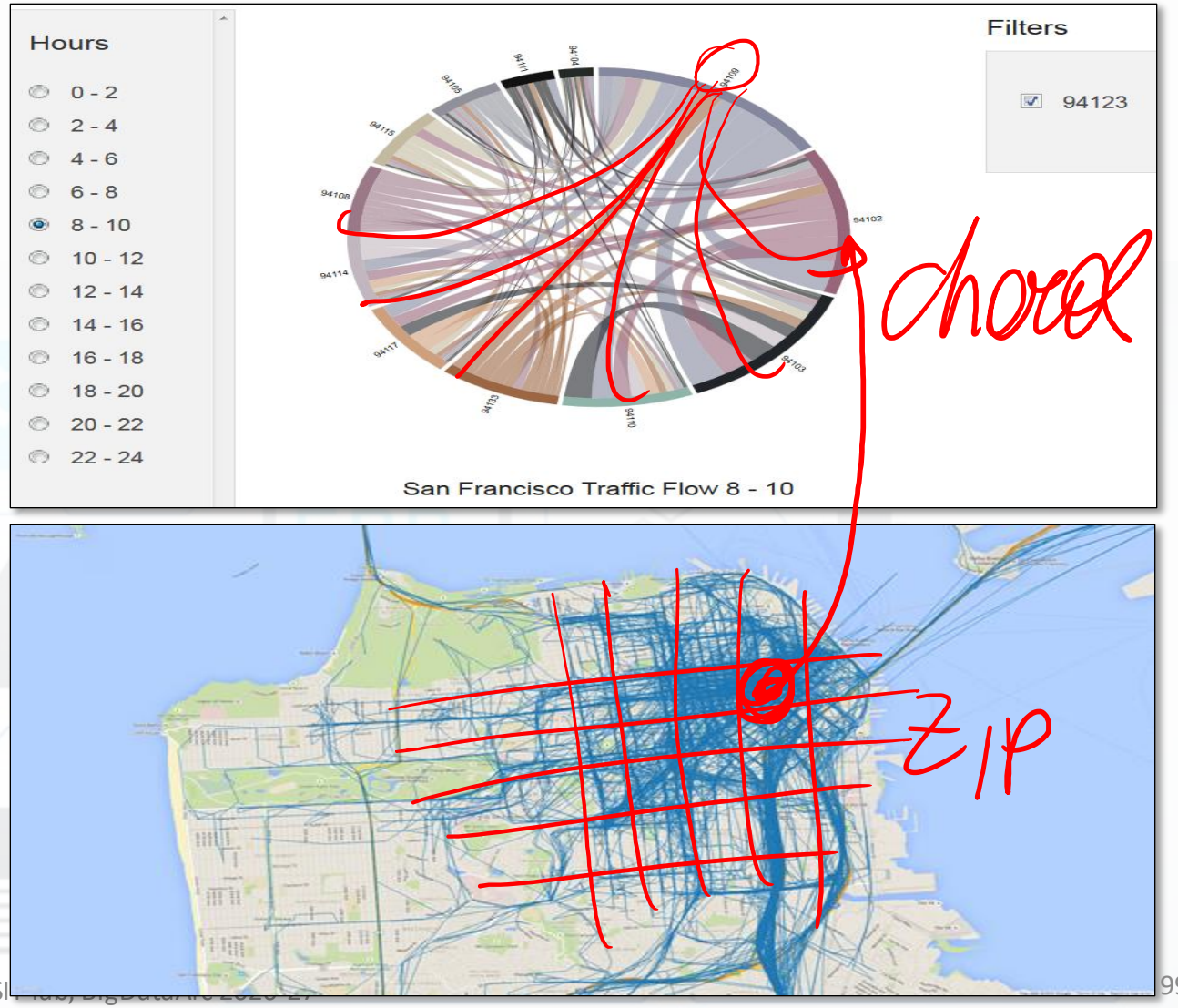
REPLICATE



Traffic and People Flow Assessment

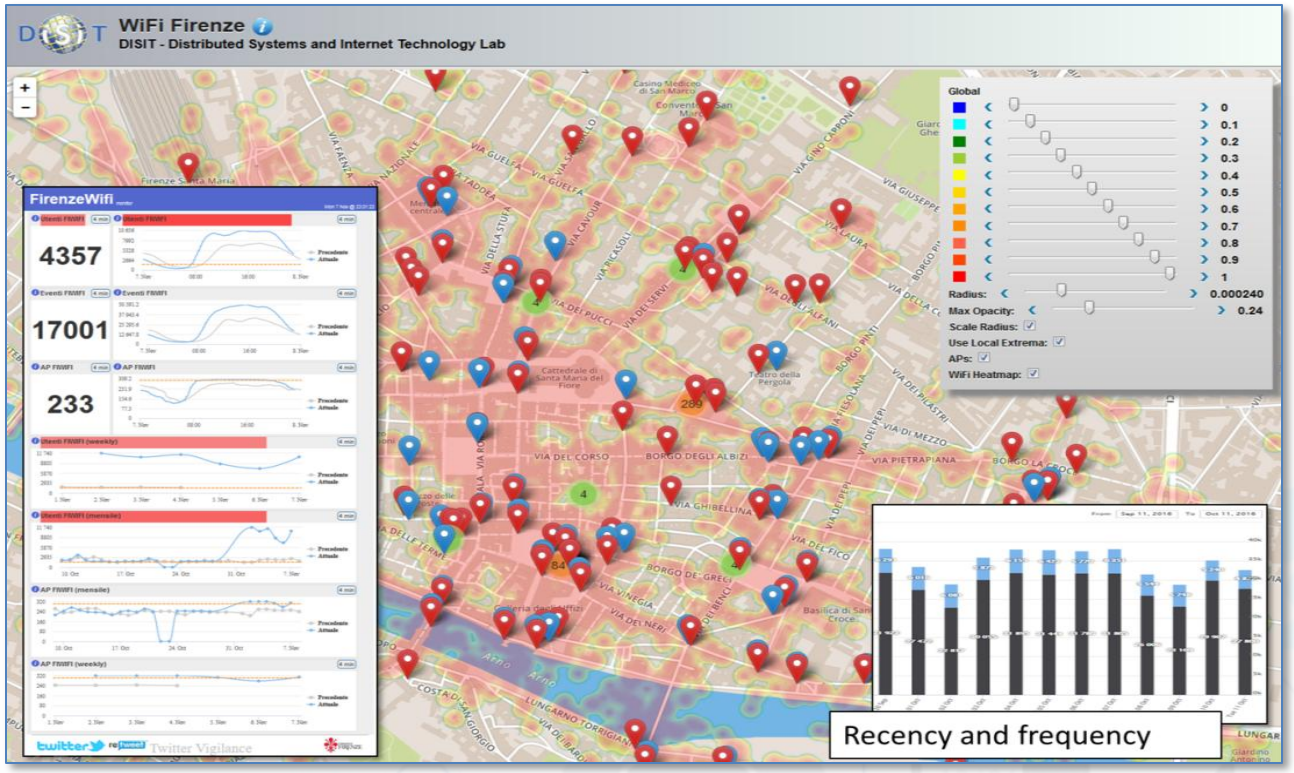
http://www.disit.org/6694

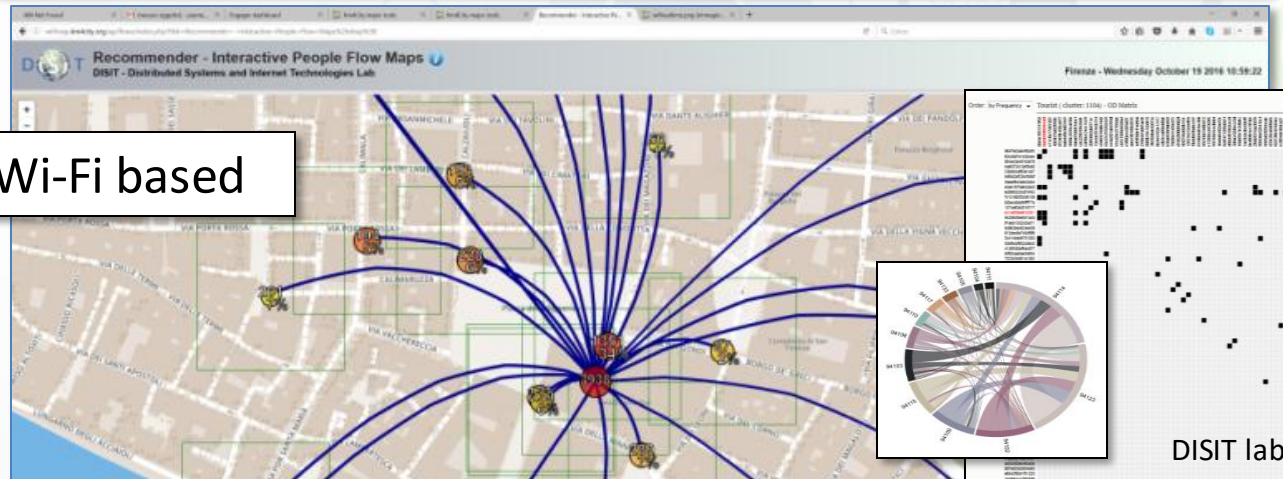
- **Origin Destination Matrix**
  - Specific Sensors, vehicle Kits, mobile App, Wi-Fi Access Points, etc.
- **Assess people and traffic flows to**
  - improve services
  - predict critical conditions on Crit. Infra.
  - take real time decisions and sending messages in push to population
  - Increase city resilience
  - optimize traffic flow
  - take decision of routing



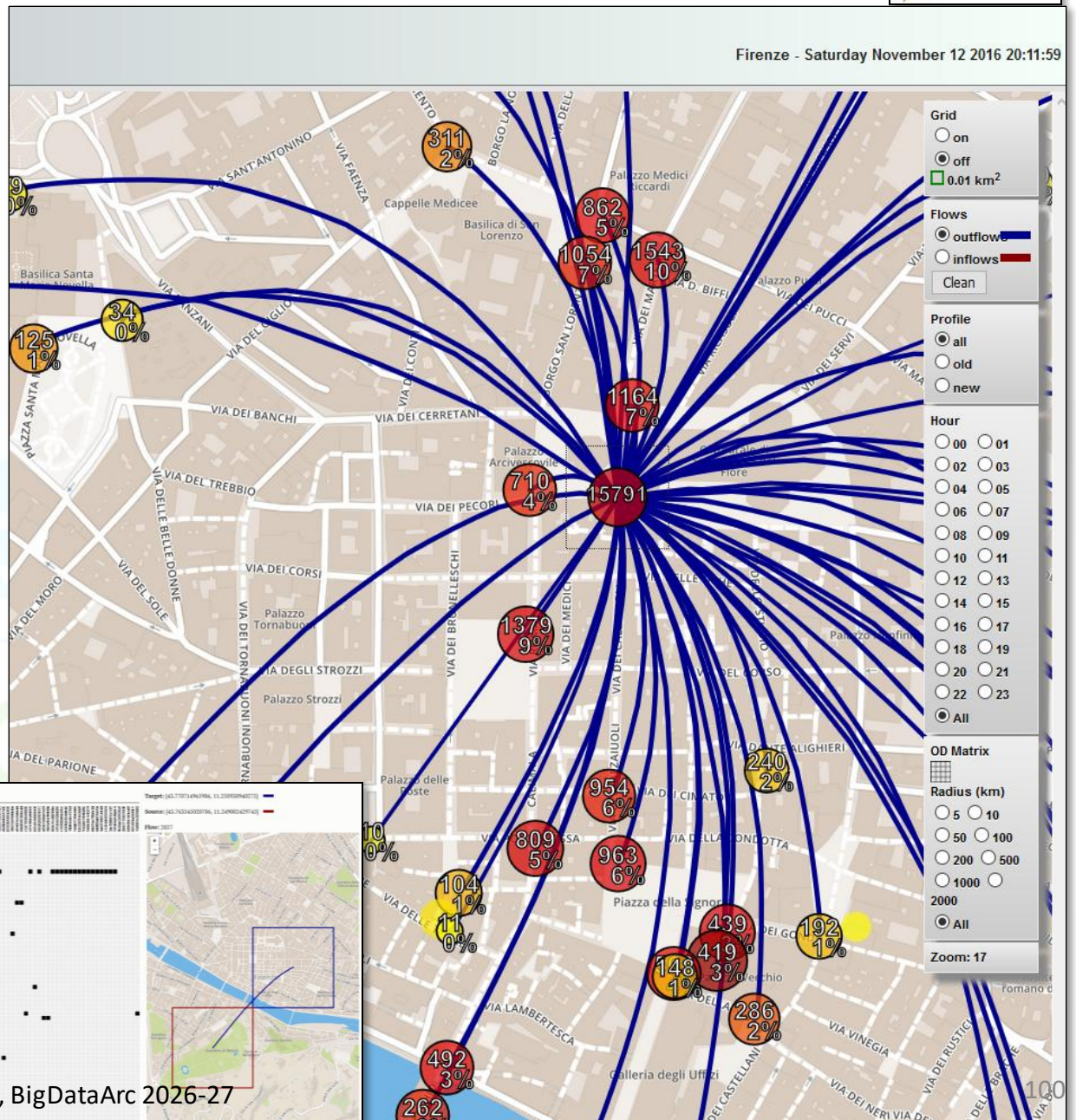
igin Destination Matrix Estimation

http://www.disit.org



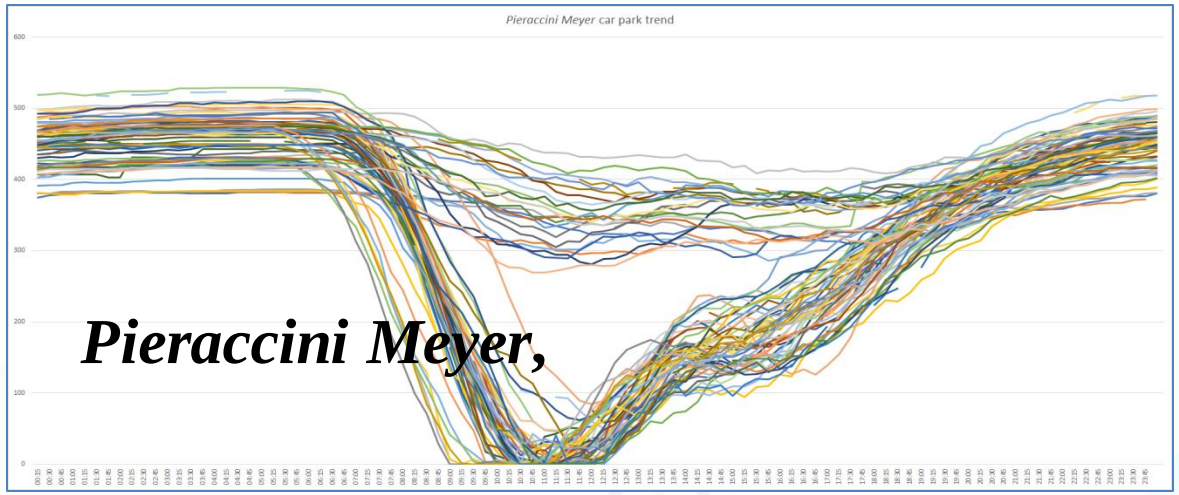


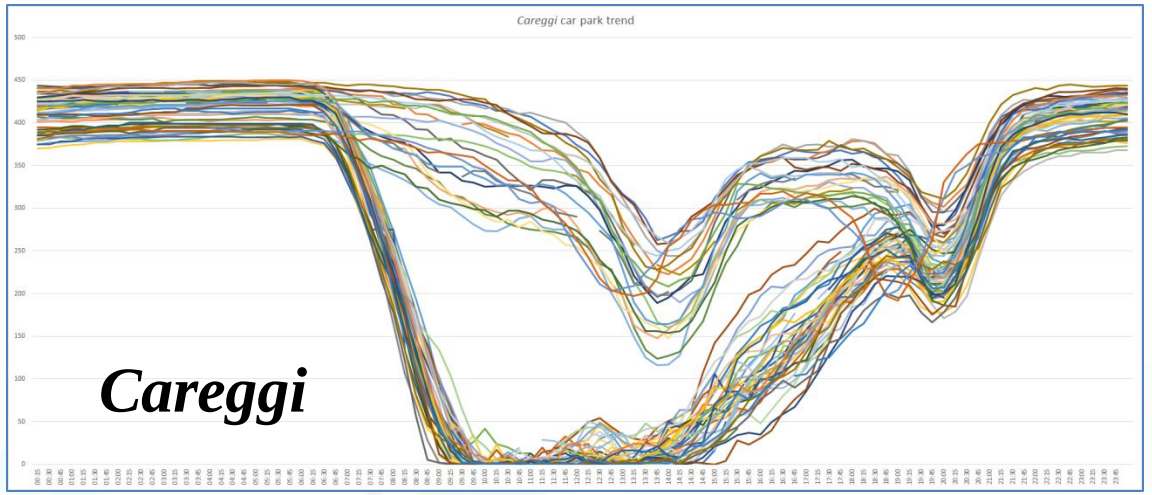
Wi-Fi based

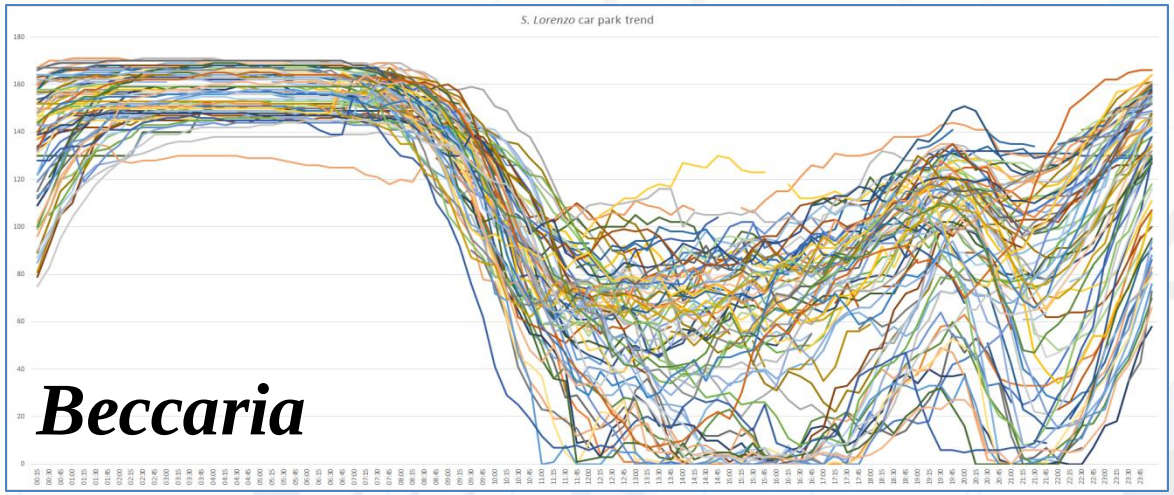


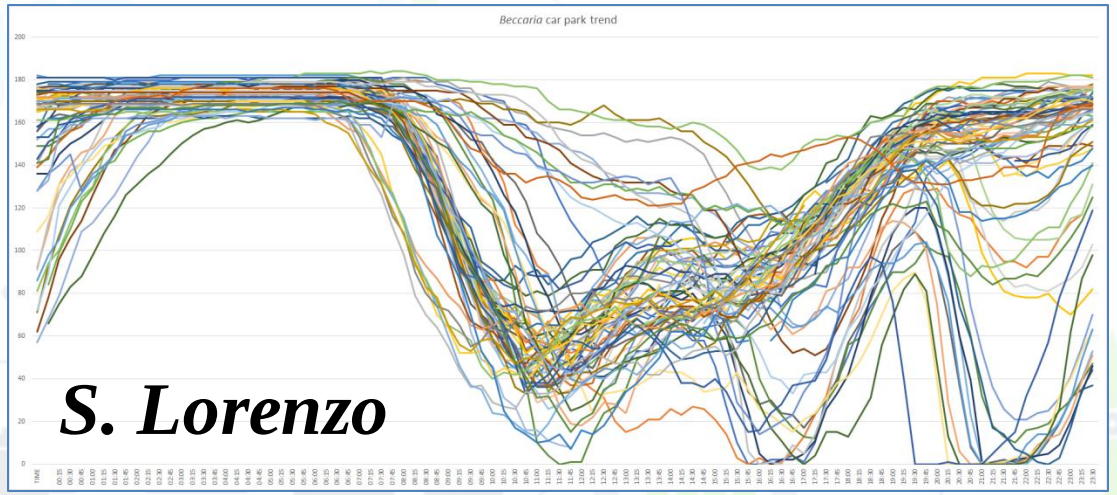
DISIT lab, BigDataArc 2026-27

Free Parking space trends









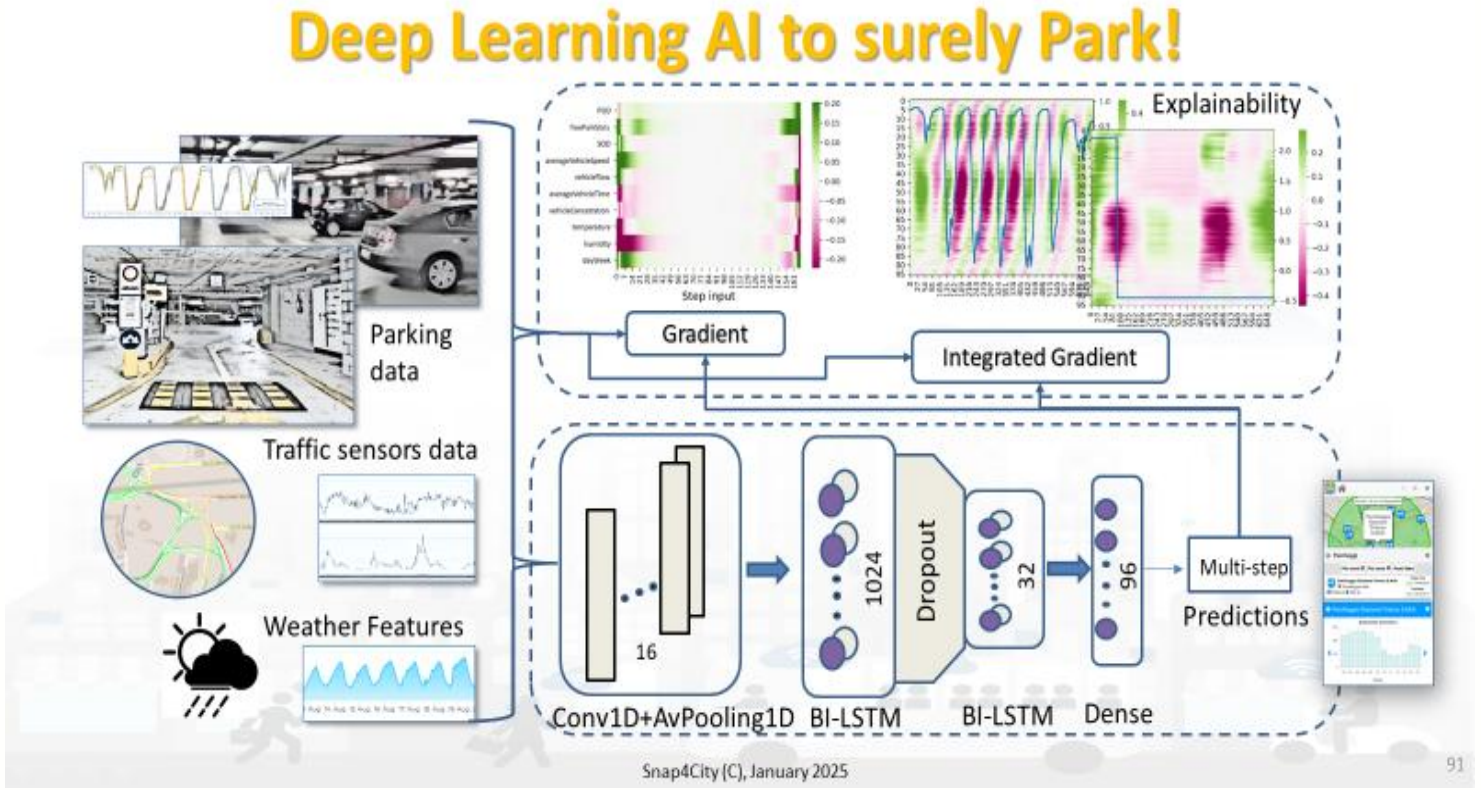
12 parking areas in Florence

Open day

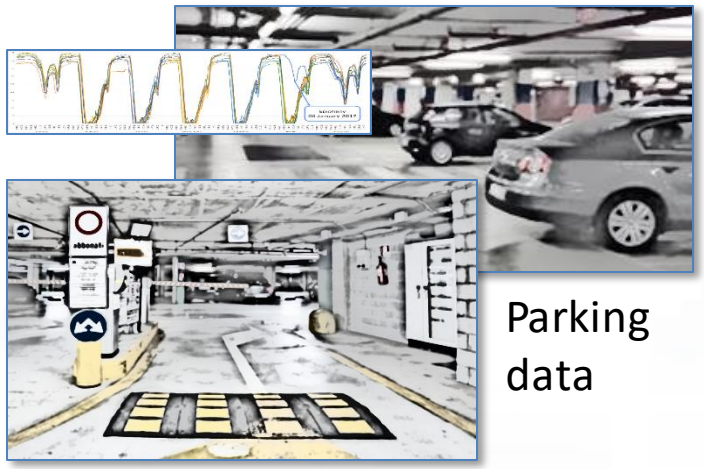
Pensa in grande, inizia da qui

Intelligenza Artificiale al servizio della città

- **Gestione Operativa, in tempo reale:**
  - **Predizioni a breve e lungo termine**
  - **Identificazione** di **anomalie** per interventi tempestivi.
  - Oggi si usano modelli di **Deep Learning:…**
    - **molti strati di reti neurali**
    - **Explainable AI: per fornire al decisore le motivazioni del suggerimento fornito dal modello di AI**



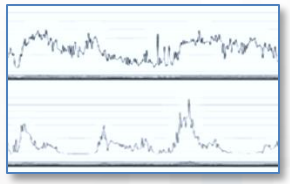
Deep Learning AI to surely Park!



Parking data

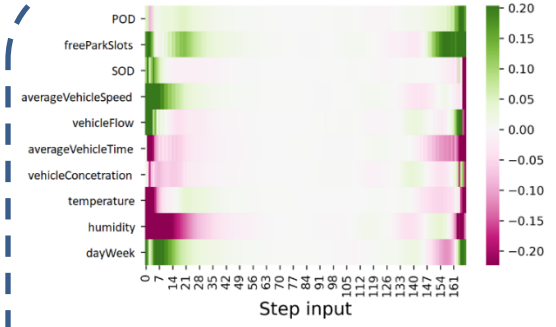
Traffic sensors data

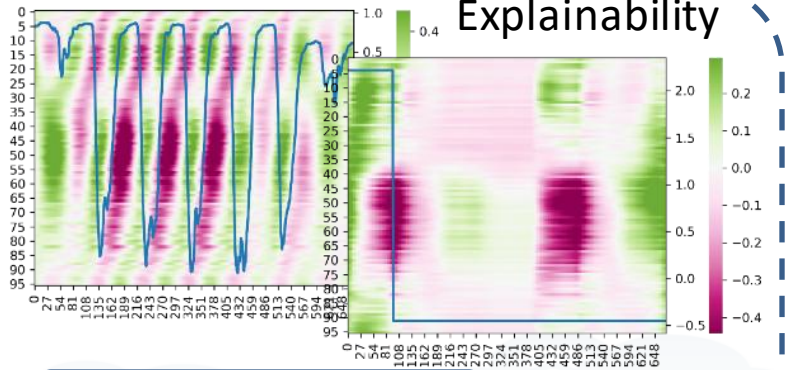




Weather Features



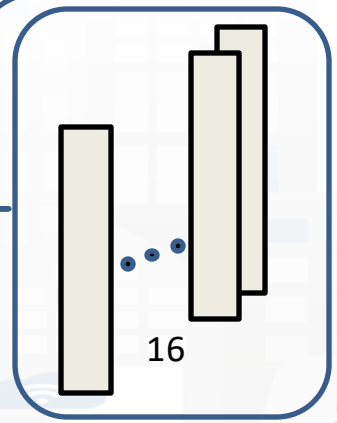


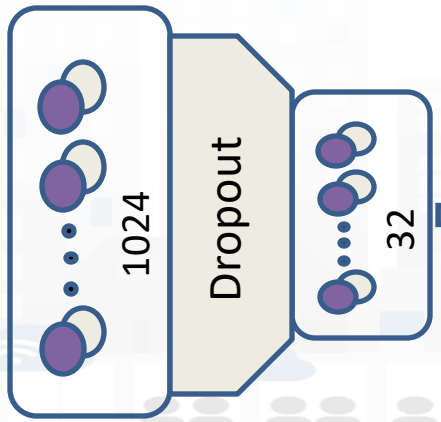


Explainability

Gradient

Integrated Gradient





Conv1D+AvPooling1D BI-LSTM BI-LSTM Dense

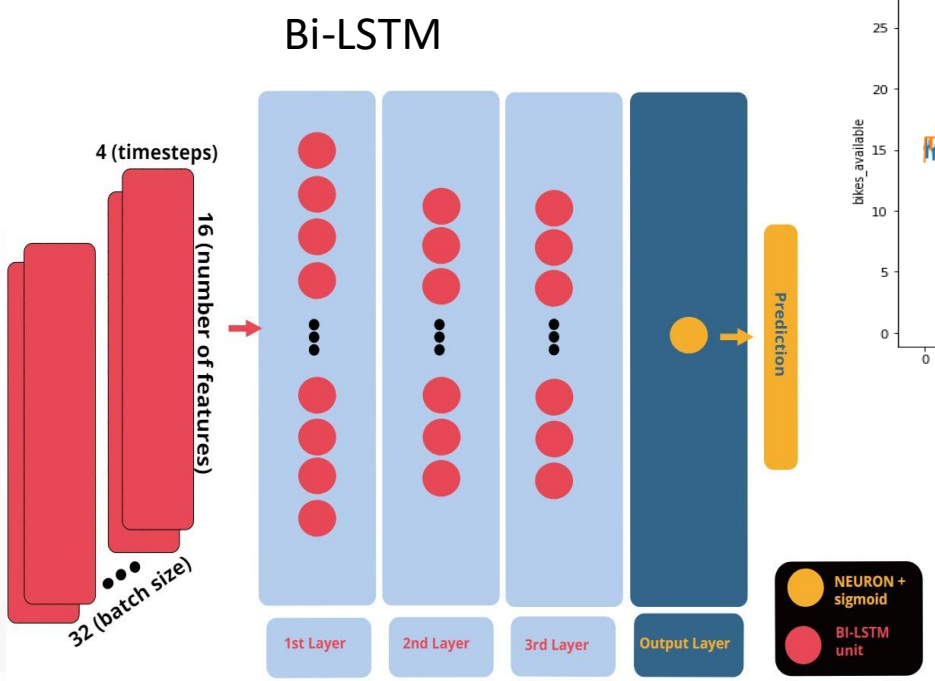
Multi-step Predictions

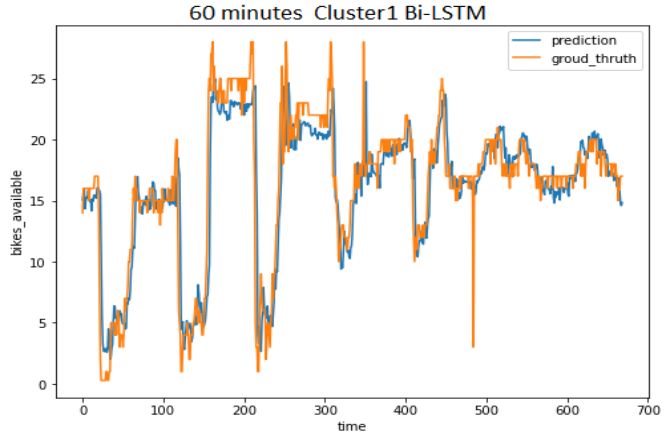


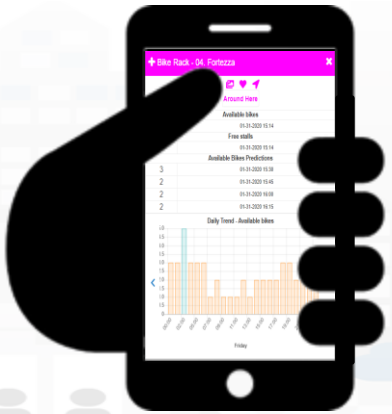
Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations







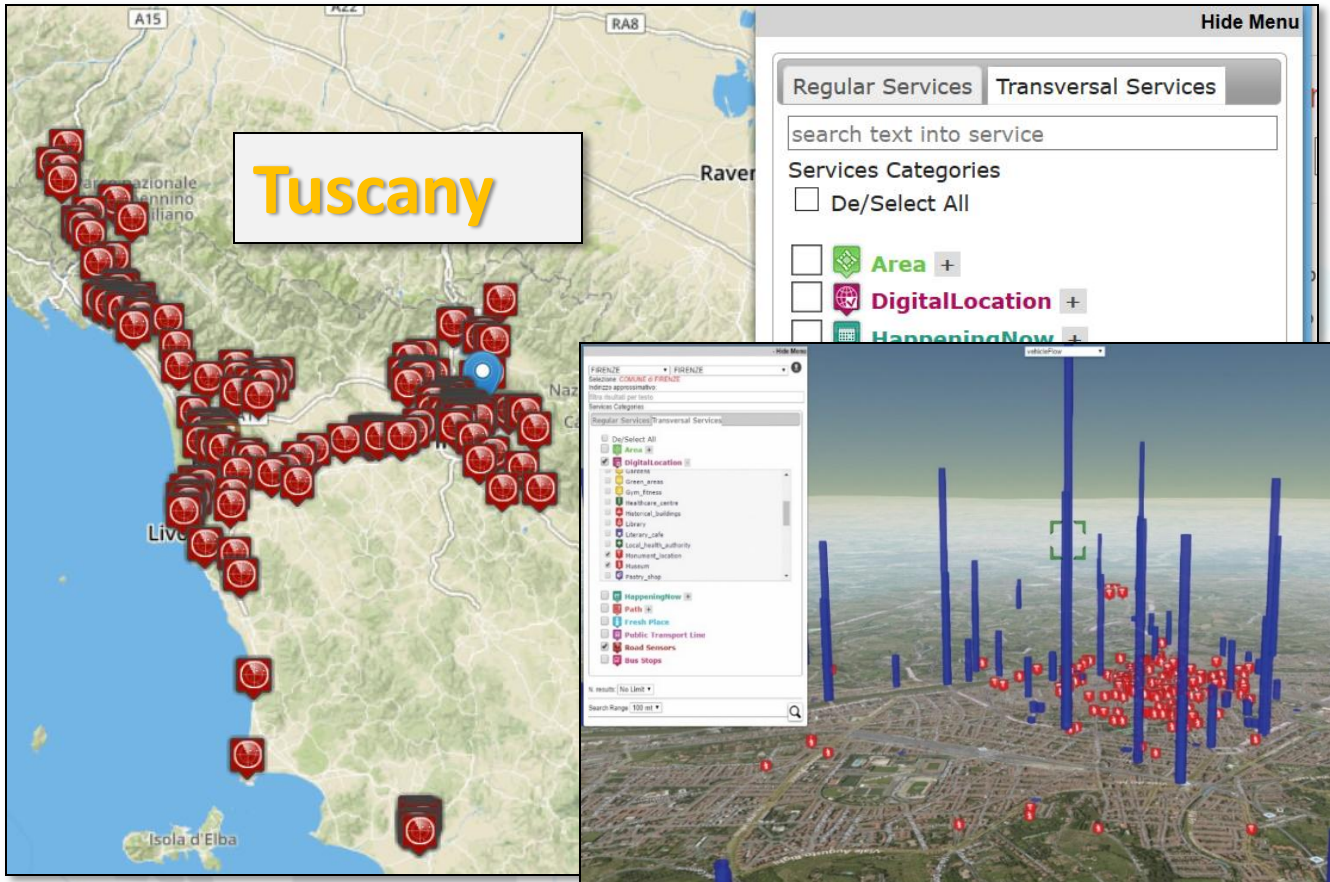




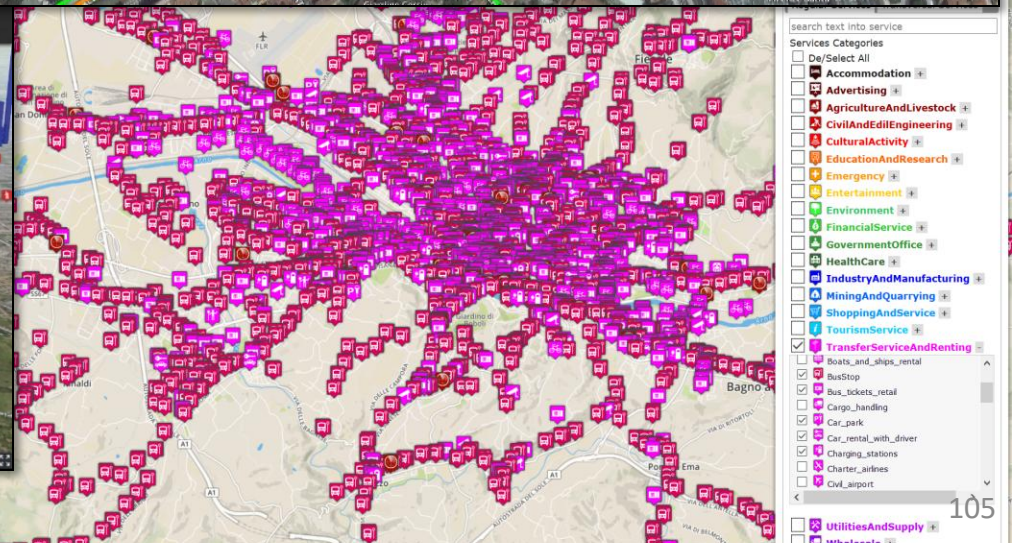
E. Collini, P. Nesi and G. Pantaleo, "Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations," in *IEEE Access*, vol. 9, pp. 124337-124347, 2021, doi: 10.1109/ACCESS.2021.3110794.
https://ieeexplore.ieee.org/abstract/document/9530580

Traffic Flow Tools

- Spire and Virtual Spires (cameras), Bluet
- Specifically located: along, around, ..





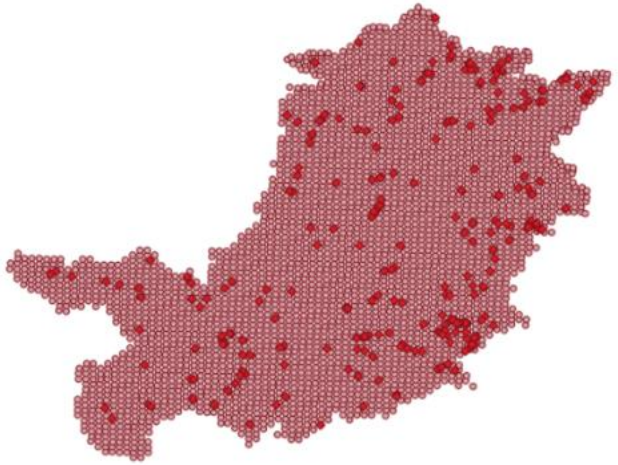


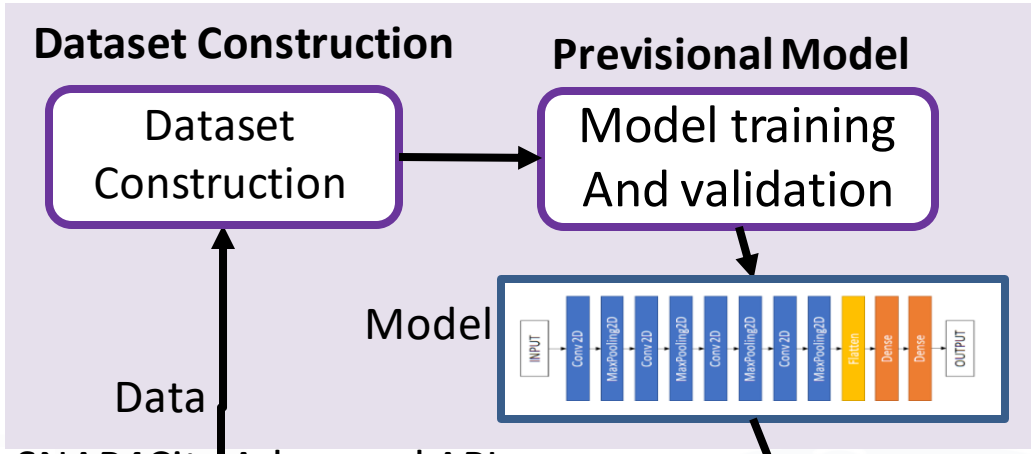


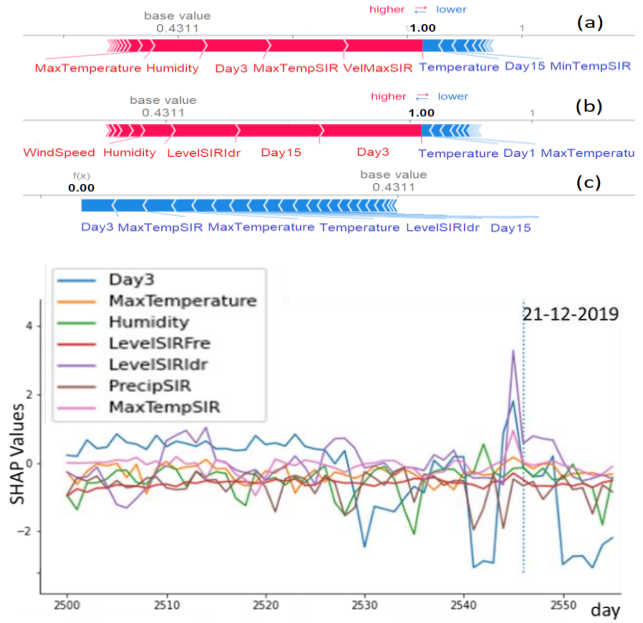
http://firenzetraffic.km4city.org

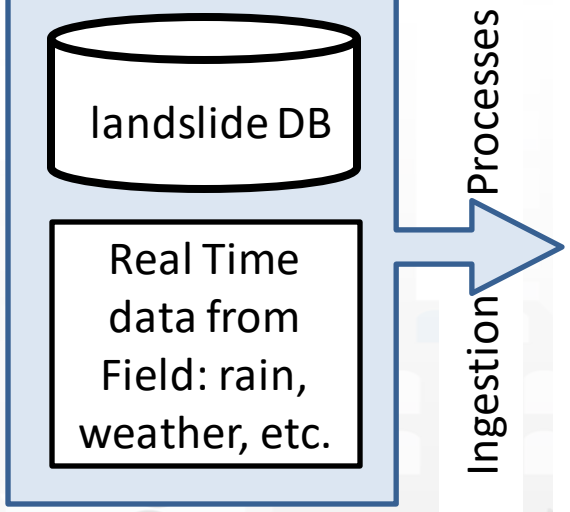
Traffic Flow reconstruction, real time

Predicting Land slides



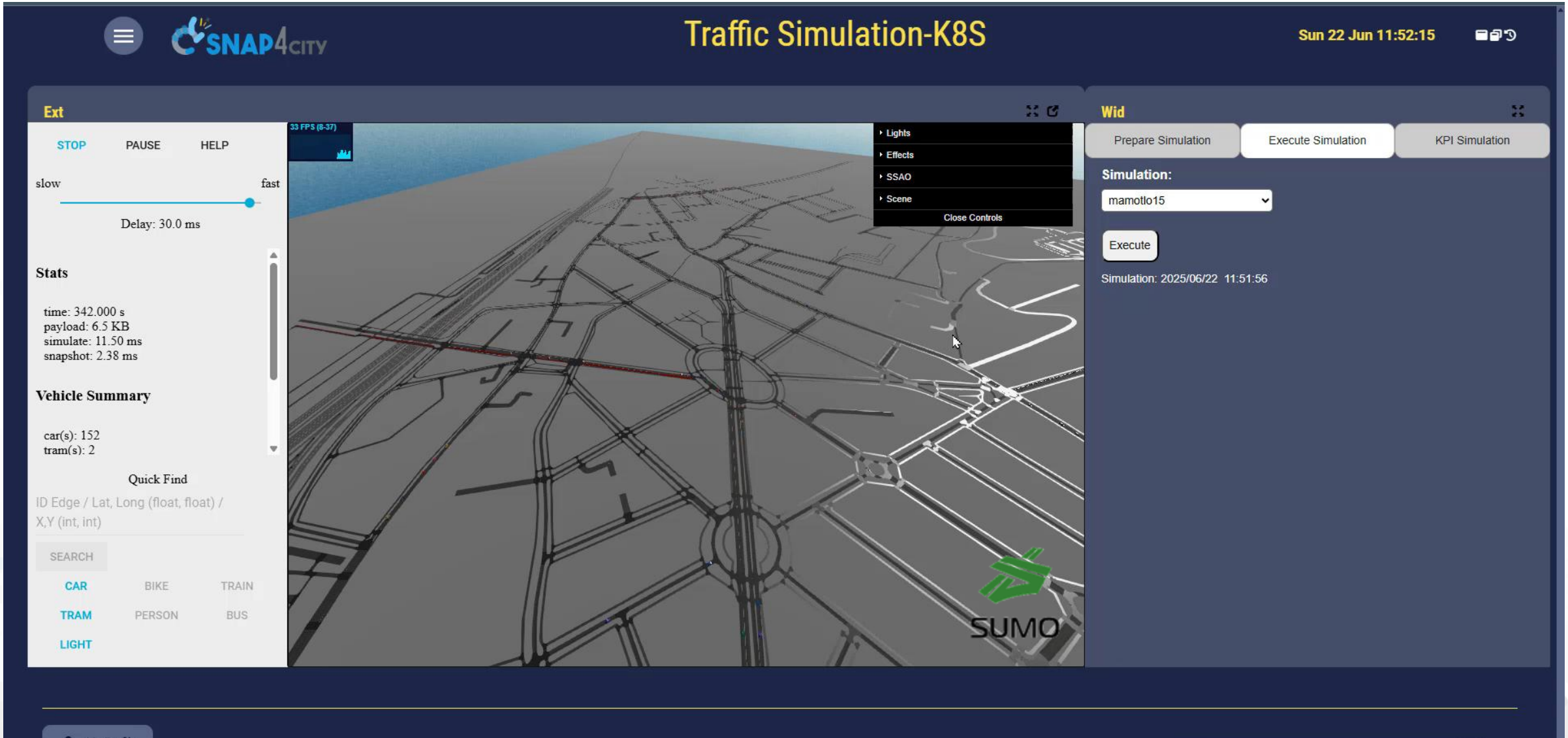




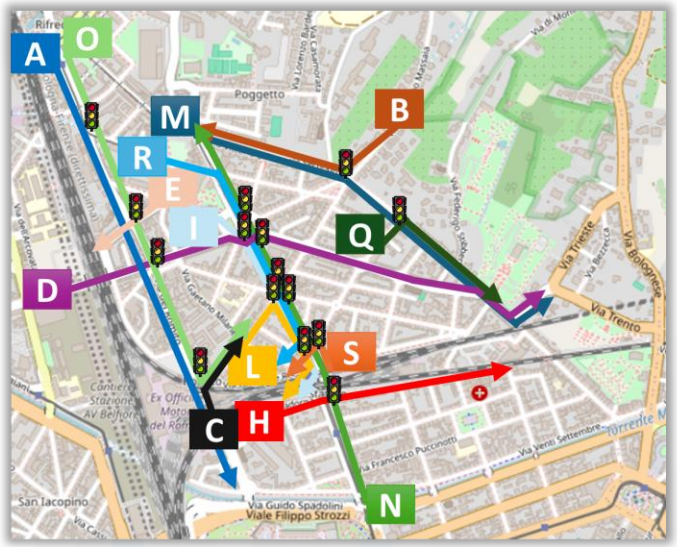


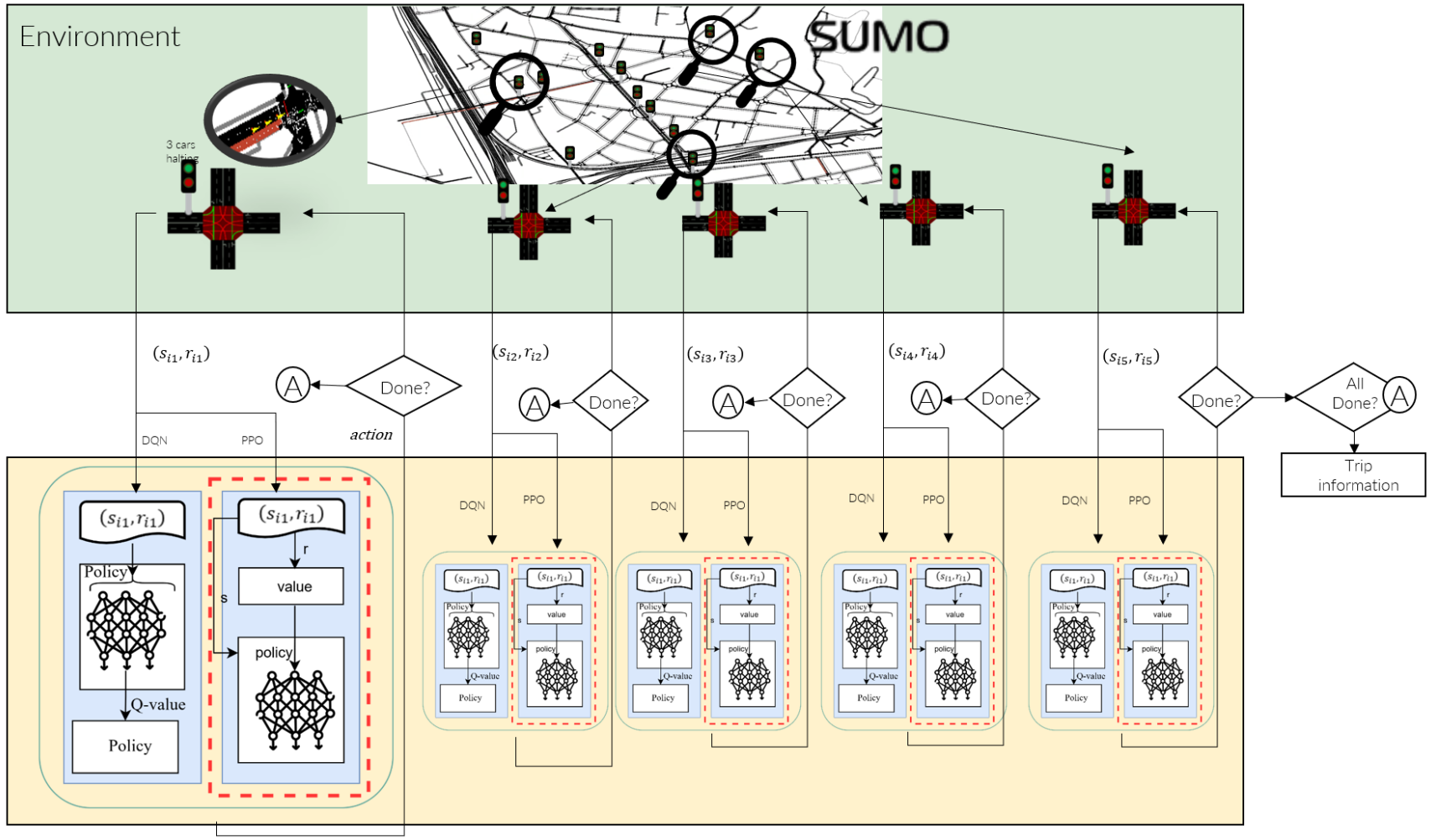
E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events with Explainable AI," in *IEEE Access*, doi: 10.1109/ACCESS.2022.3158328.
https://ieeexplore.ieee.org/abstract/document/9732490

S. Bilotta, Z. Fereidooni, L.A. Ipsaro Palesi, P. Nesi, "Macroscopic GA-based Multi-Objective Traffic Light Optimization Prioritizing Tramways", Applied Soft Comp. Journal, Elsevier, 2025.



Multi Agent DRL





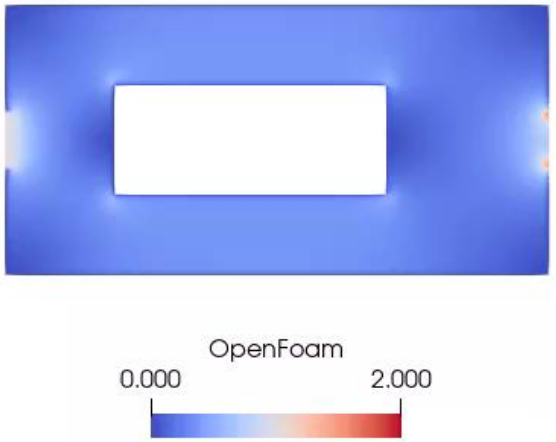
Z. Fereidooni, L.A. Ipsaro Plaesi, P. Nesi, Multi Agent Optimizing Traffic Light Signals Using Deep Reinforcement Learning, IEEE Access, 2025.

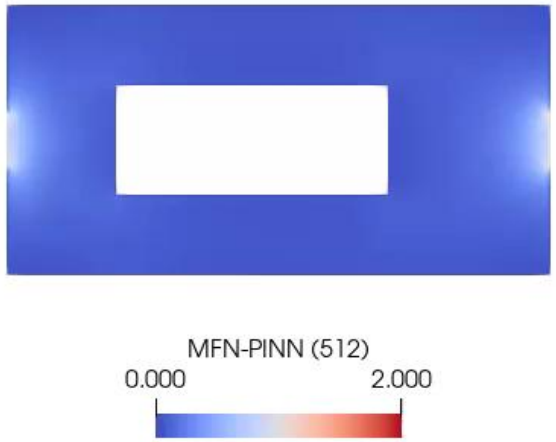
PINN: Physically Informed Neural Neworks Models

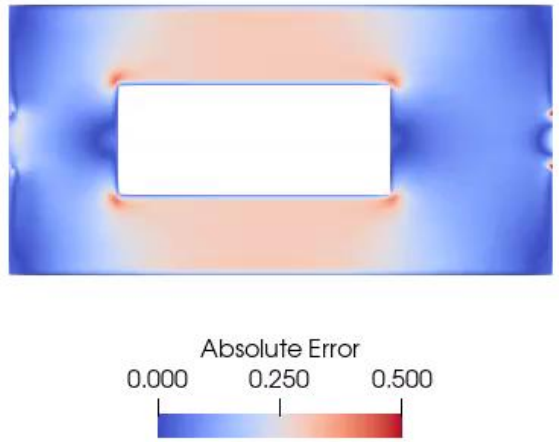
- **Solving Navier-Stokes PDE** (partial differential equations) equation, **via PINN** approach
  - Reduction of computing costs for simulating load effect into the autoclaves curing process
  - Validation wrt Open Foam
  - Precision on steady and transitory cases
  - Definition of Transfer Learning techniques
- Videos on https://www.snap4city.org/1010

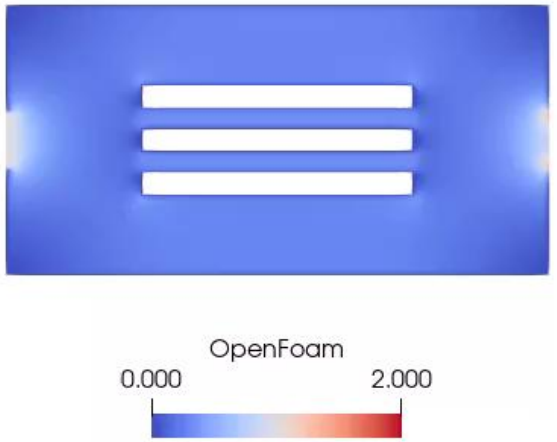


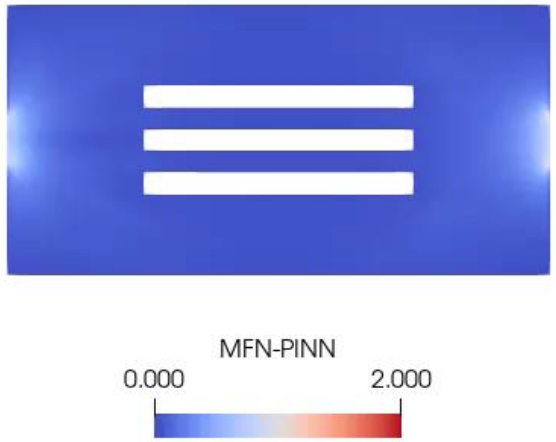
Comparison of PINN vs OpenFoam and error

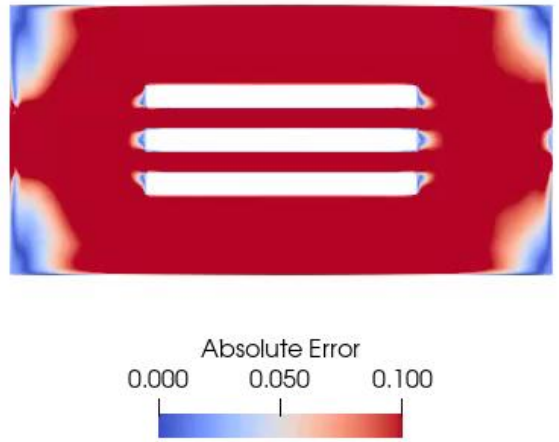


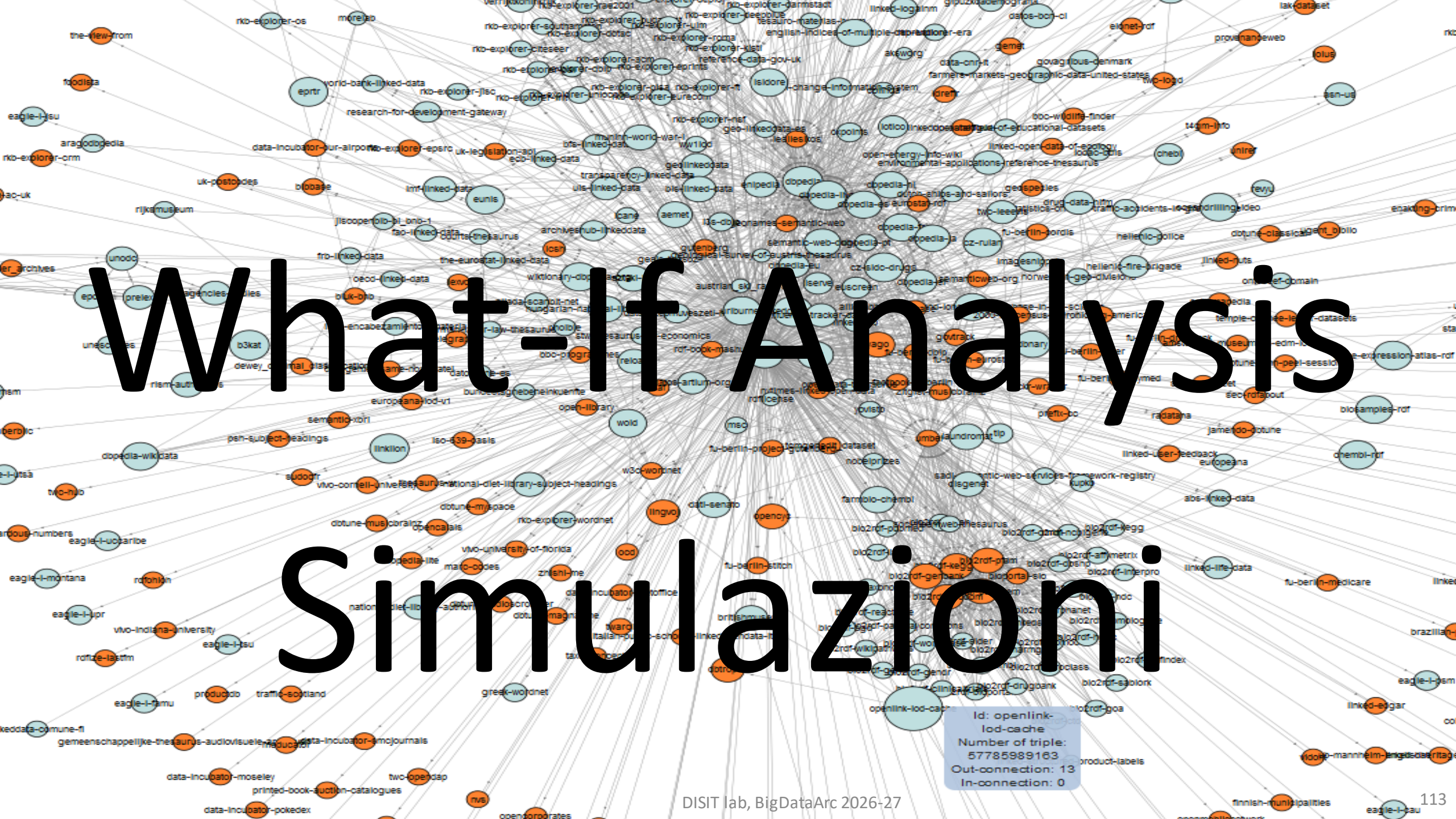






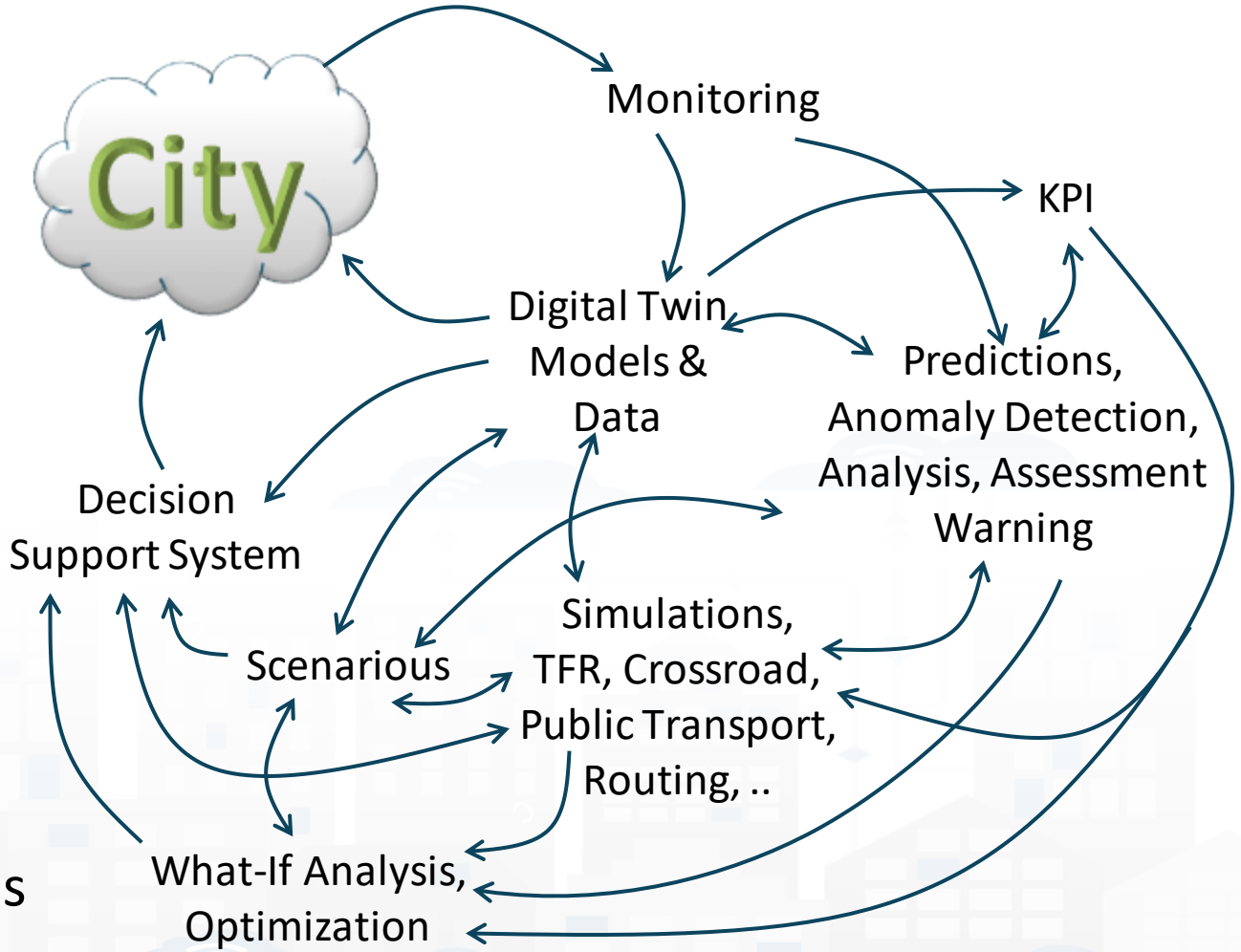





What-If Analysis
Simulazioni
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0

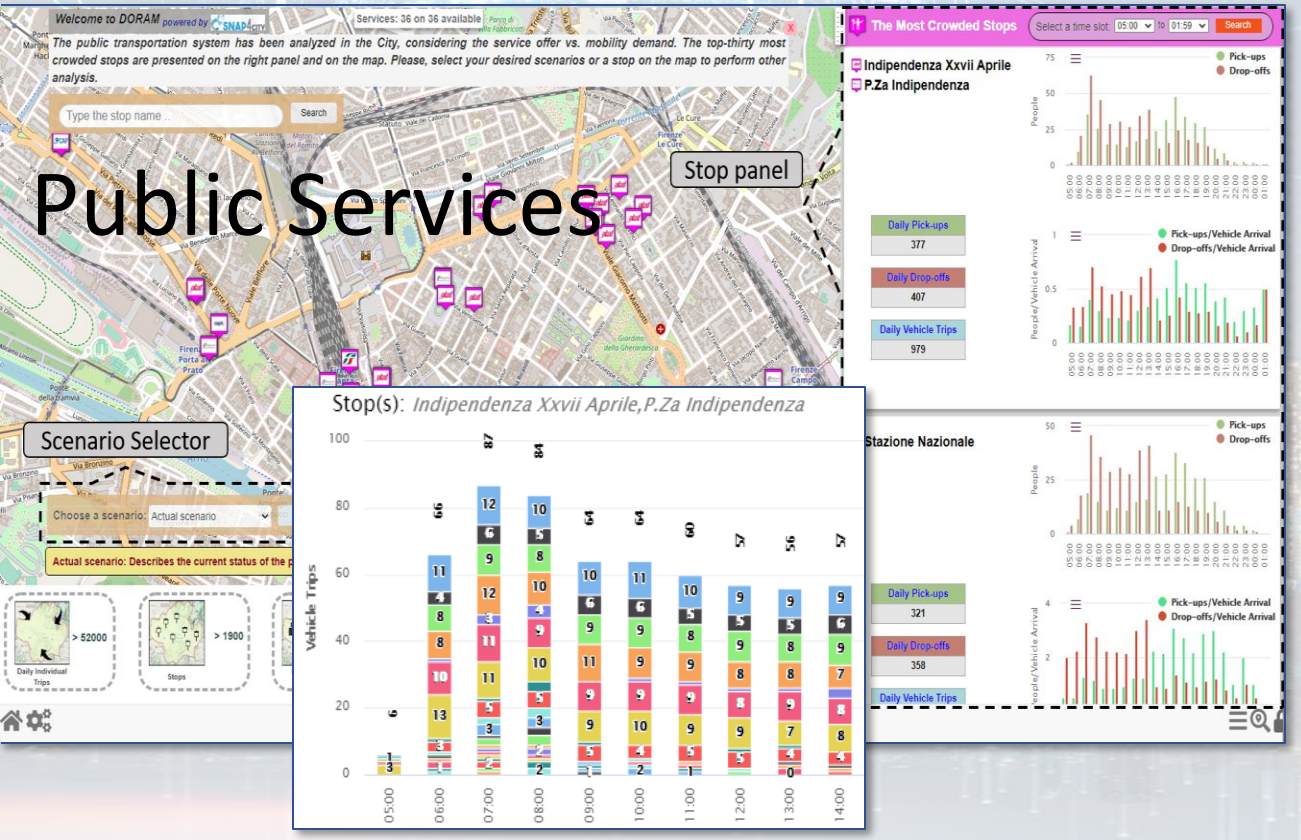
Main tasks

- **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

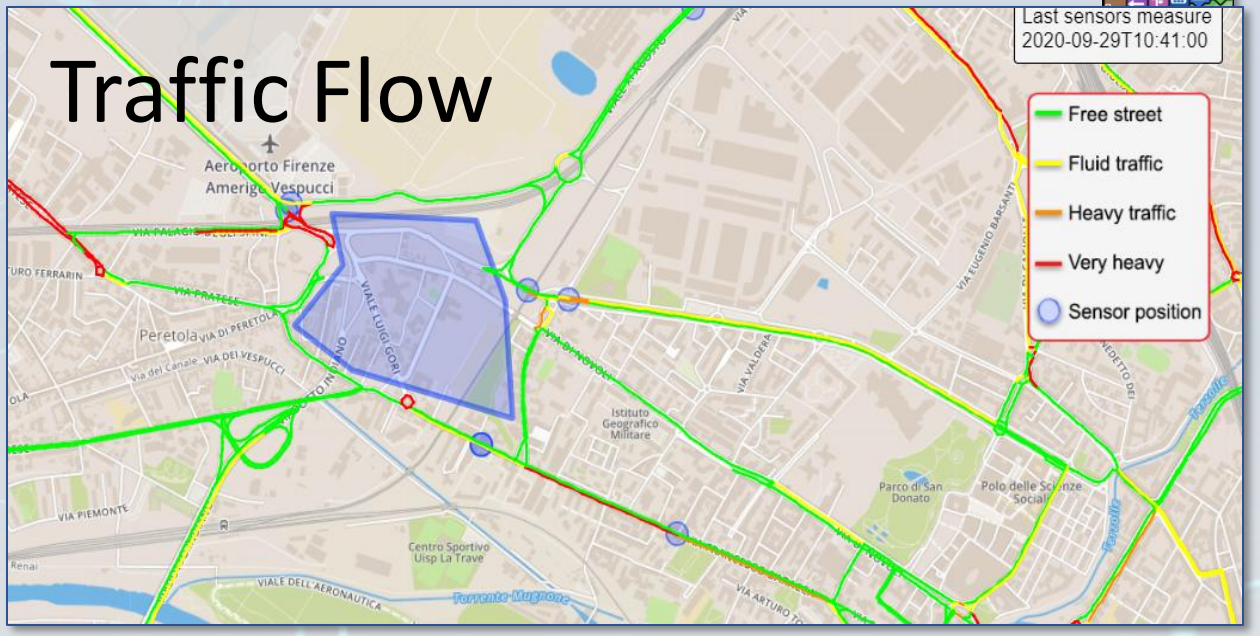


What-if Analysis

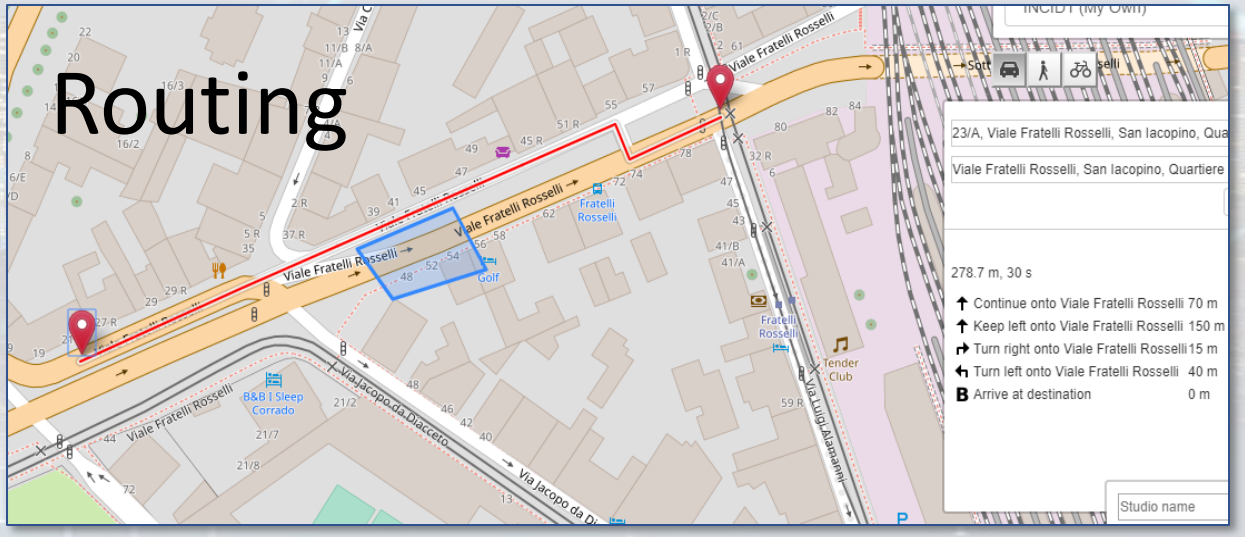
- Definition of scenarious impact on
  - Traffic, Pollutant, parking, public transport, private flows, etc.
  - KPI analysis



Public Services



Traffic Flow



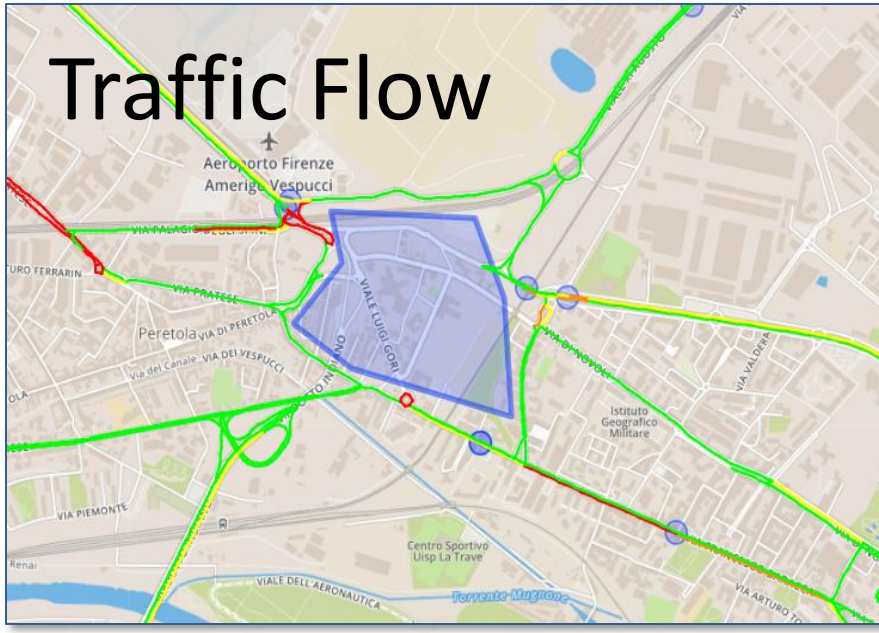
Routing

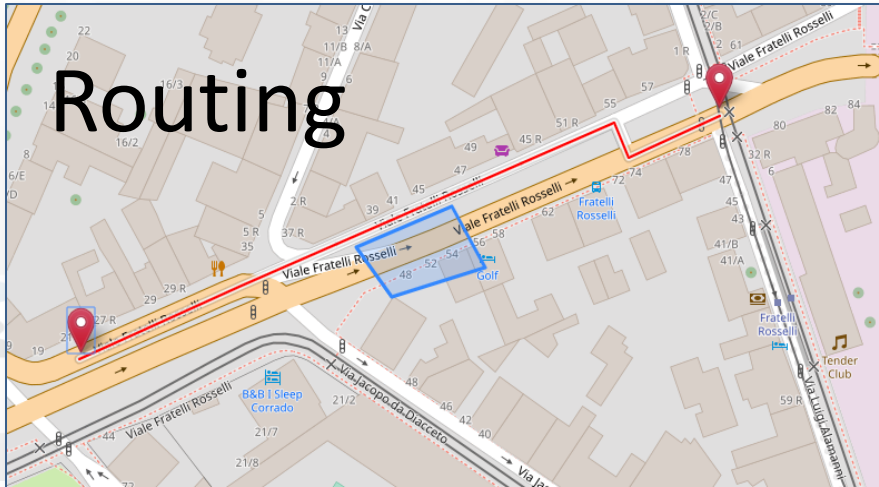
What-If analysis



Decision Support Systems, What-if

- **Event planning, via what-if analysis**
  - Change in the graph structure of the city
  - Impact on the flow of people and vehicles
  - Adaptation: public transport, traffic, pedestrian management, etc.
- **Immediate reaction to natural events or not**
  - Everything is ready and updated in real time
  - Each view is contextualized in terms of data: descriptive and prescriptive
- **Digital Twin**
  - More detail in the context integrated data
  - Greater realism in deductions and representations
  - Less fragmentation and non-uniformity in the views to support decisions



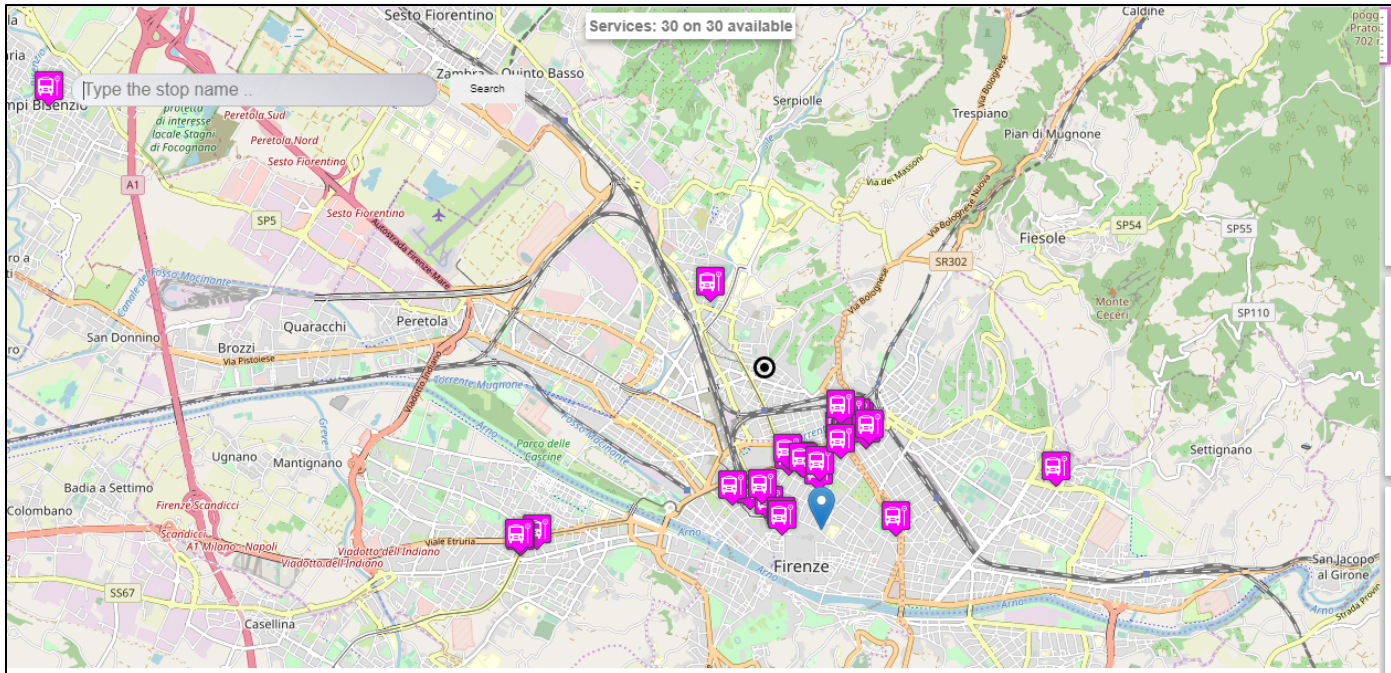


Multi-Widget Map



https://main.snap4city.org/view/index.php?iddasboard=OTc2

Bus Stop Analysis: identification of criticalities




> 42300

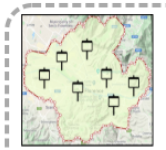
Daily individual Production Trips


> 52900

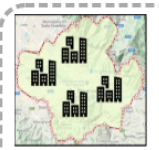
Daily Individual Attraction Trips


21289

Daily bus trips


1875

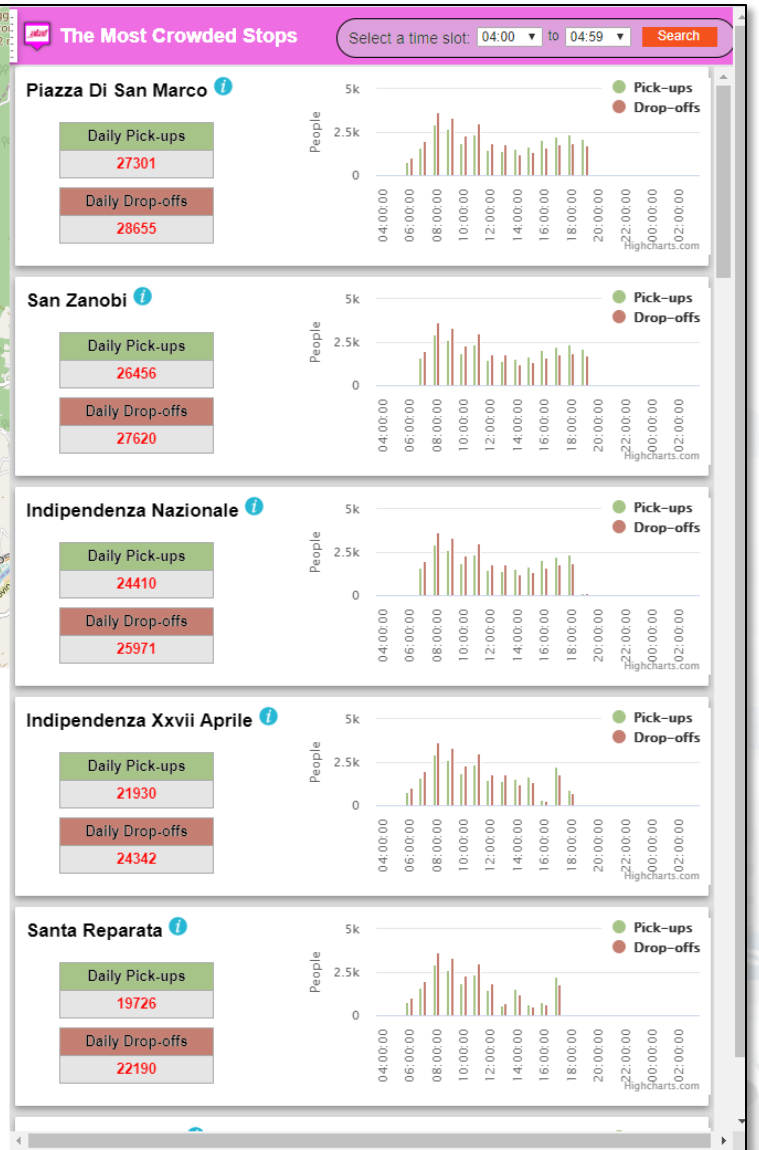
Bus Stops


31070

Residential Buildings


31059

Service Providers



Open day

Pensa
in grande,
inizia da qui

Caso d'uso: Pianificazione Urbana

11 SUSTAINABLE CITIES AND COMMUNITIES

- **Simulazioni e modelli**
  - scenari di sviluppo urbano
- **Ottimizzazione**
  - infrastruttura di traffico
  - riduzione dei tempi
  - riduzione emissioni, etc.
- **Progettazione**
  - soluzioni sostenibili e inclusive
  - migliorare la vivibilità
- **Digital Twin**
  - Come base per il dialogo partecipato



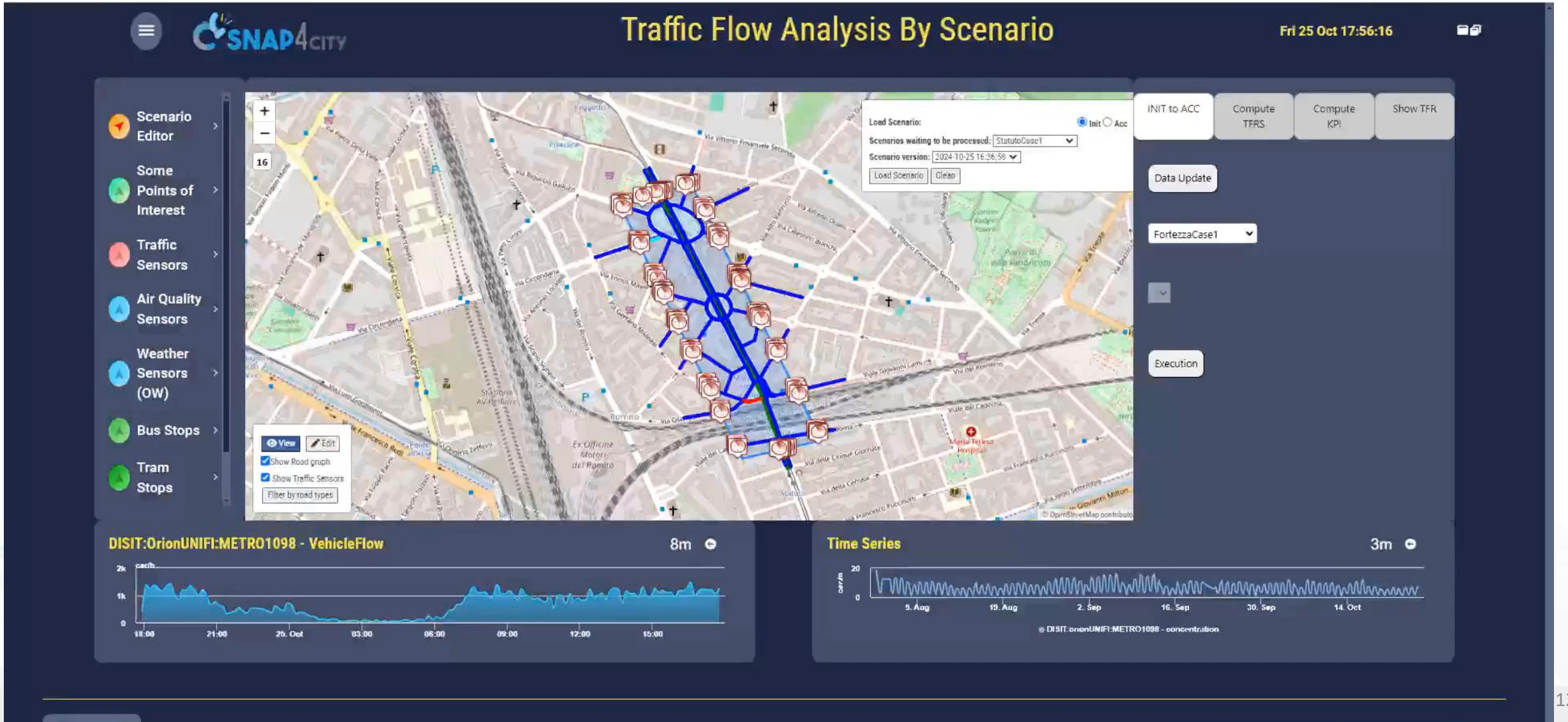
Future Artificial Intelligence Research

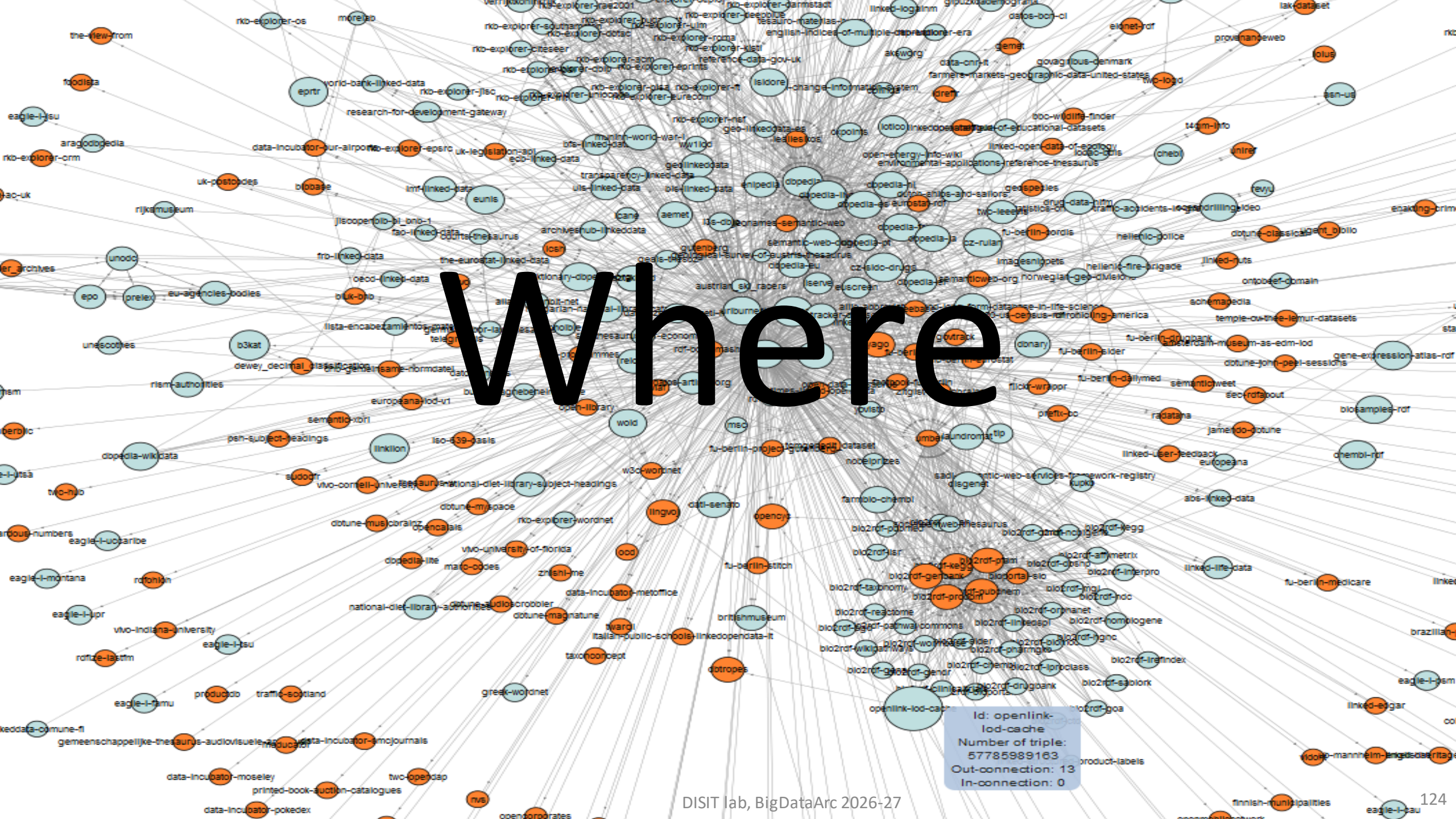
MOST CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

UNIVERSITÀ DEGLI STUDI FIRENZE
Da un secolo, oltre.

UNIVERSITÀ DEGLI STUDI FIRENZE
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB
DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB
SNAP4CITY

Optimization of Traffic Light Plan

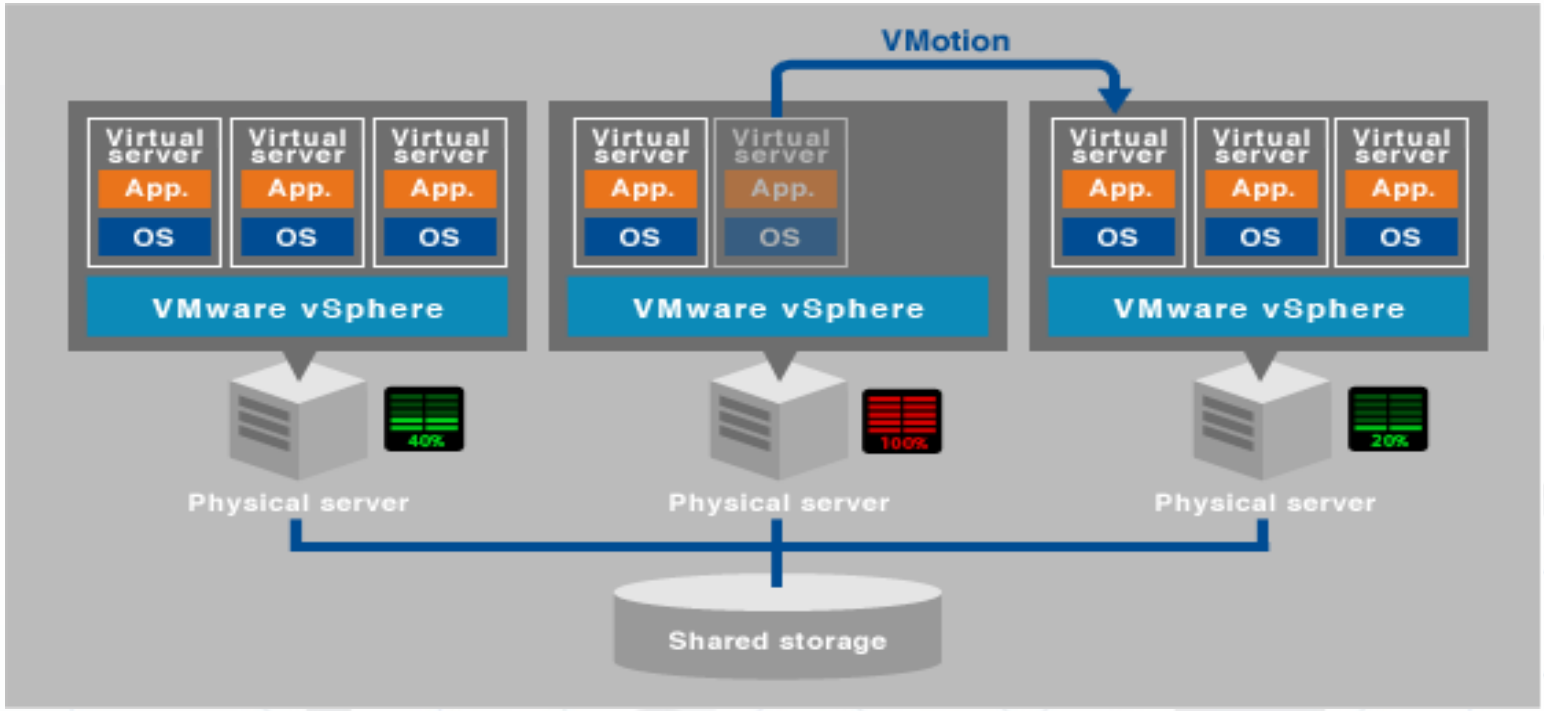



Where
Id: openlink-lod-cache
Number of triple: 57785989163
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In-connection: 0



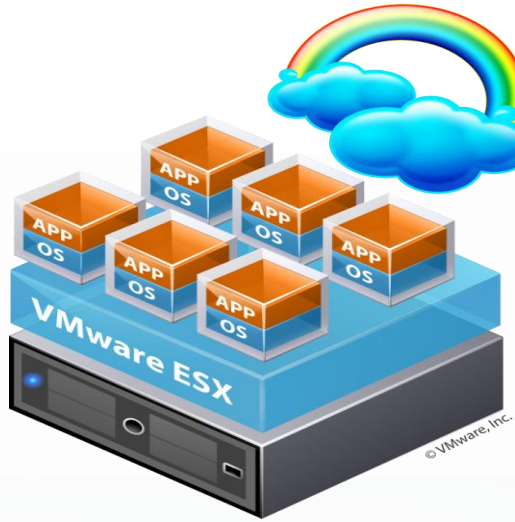
Virtualizzazione e Cloud

- HA: High Availability,
  DRS: Distributed Resource Scheduler





Cloud computing e Virtualizzazione



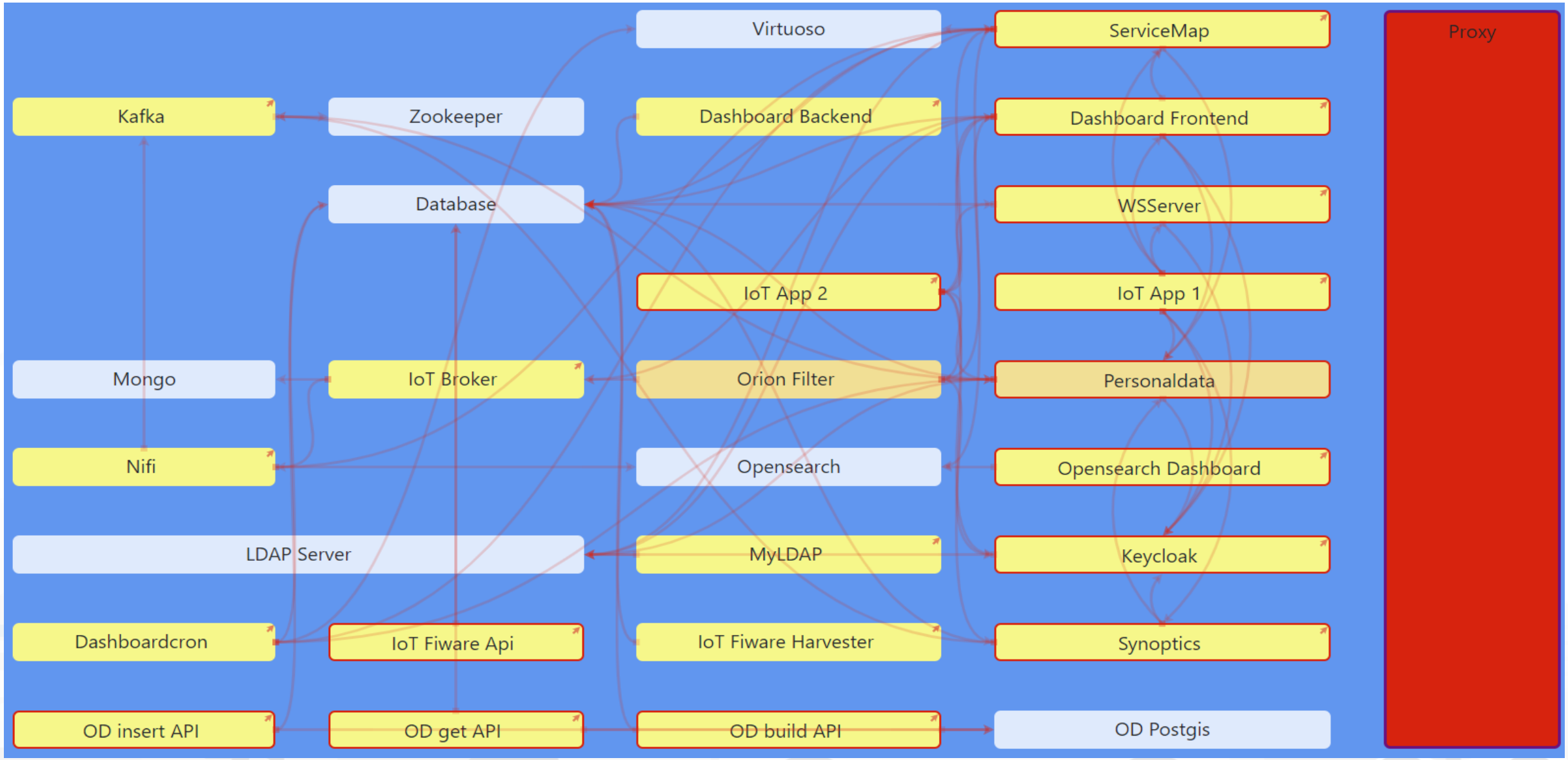
- **Motivations for Cloud computing and Virtualization**
- **Virtual Machine concepts:** emulation, para-virtualization, snapshots
- **Cloud Computing,** cloud vs grid, goals of cloud computing
- **High Availability,** Workload Balancing
- **vSphere Infrastructure,** Vmotion, Power Management, Resource Scheduling, Fault Tolerance
- **Security on the Cloud**
- **Conversions** among VM and physical machines
  - Covnersions: P2V, V2V
- **vCenter, datacenters and cluster management**
  - Performance analysis for the cloud
- **Comparison** among Cloud computing solutions
- **ICARO project**



High Availability: Hot spare, hw

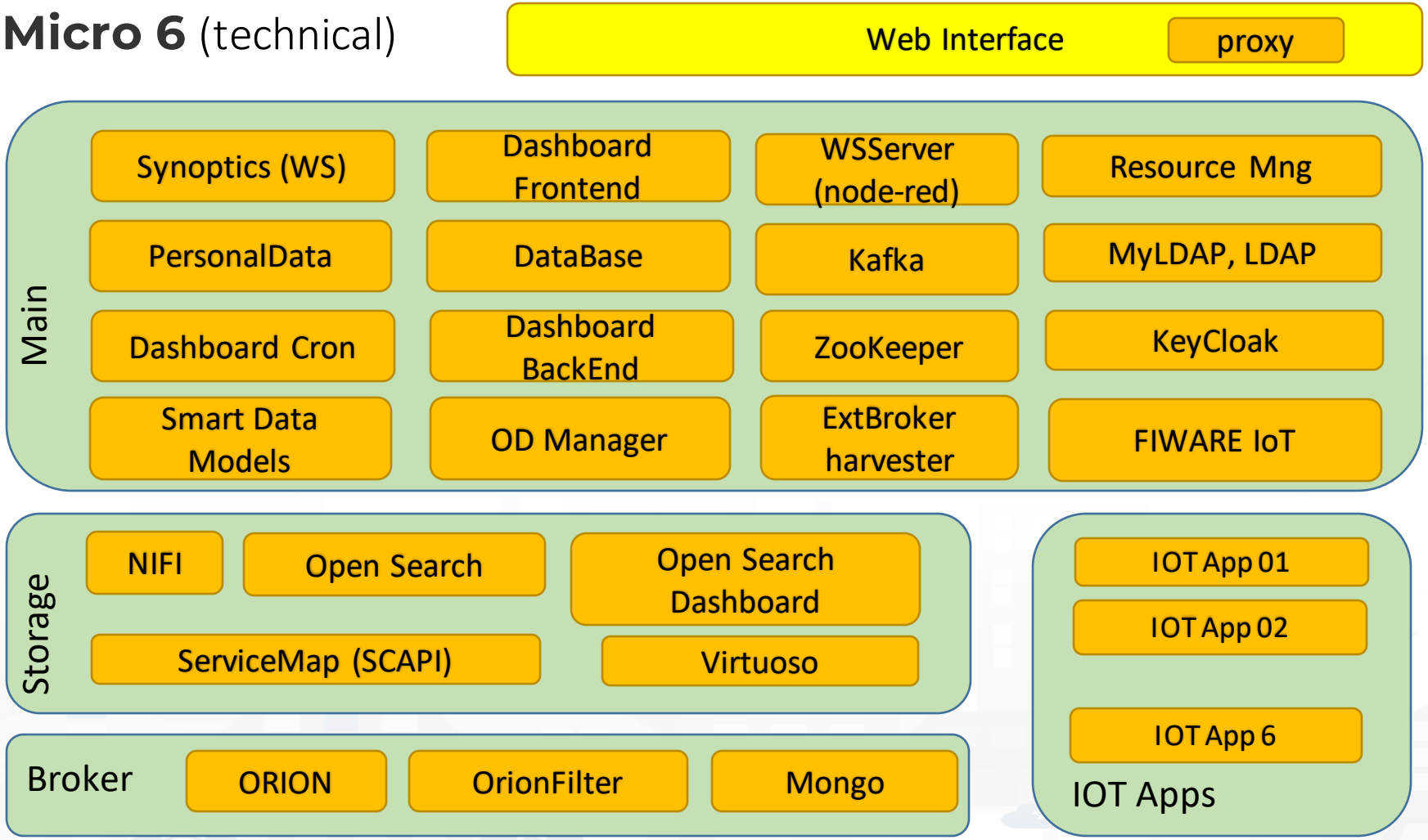


- Three separate networks cards
  - Front end
  - Heartbeat
  - Database NAS/SAN
- UPS/APC solutions with
  - 2 UPS, each of which with network card
- NAS/SAN
  - Raid 5 or 6, 60
  - Fiber connection

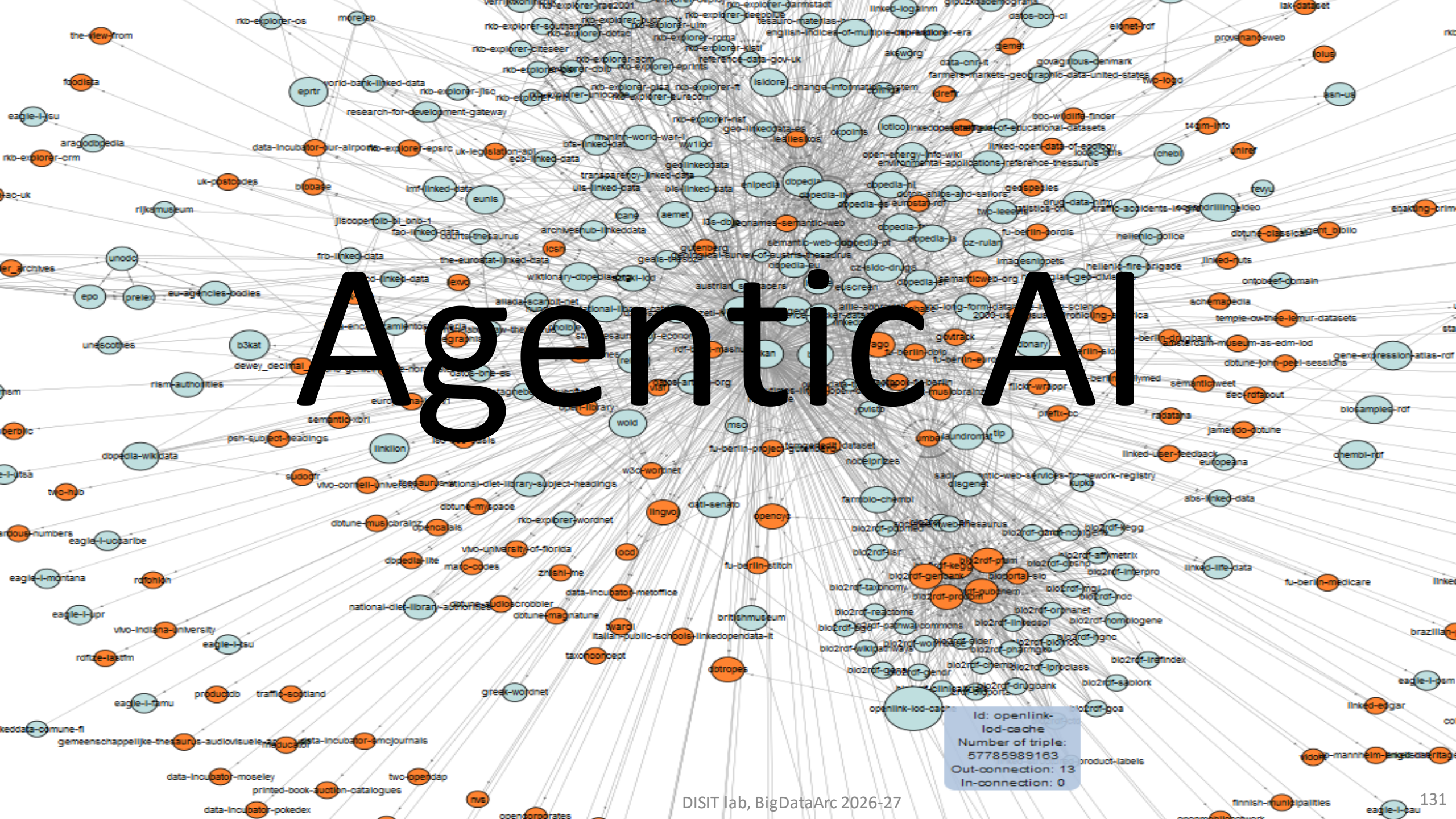

Virtuoso
ServiceMap
Proxy
Kafka
Zookeeper
Dashboard Backend
Dashboard Frontend
Database
WSServer
IoT App 2
IoT App 1
Mongo
IoT Broker
Orion Filter
Personaldata
Nifi
Opensearch
Opensearch Dashboard
LDAP Server
MyLDAP
Keycloak
Dashboardcron
IoT Fiware Api
IoT Fiware Harvester
Synoptics
OD insert API
OD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

Micro 6 model

Micro 6 (technical)



1Hour installation and ready to use


Agentic AI
Id: openlink-lod-cache
Number of triple: 57785989163
Out-connection: 13
In-connection: 0



Logged in as:
edoardo_tester

Your Profile

Logout

SnapAssistant model:

Llama3.3

New Chat

EdoChat1

EdoChat2

EdoChat3

EdoChat4

prova

chatNuova

chatTest1LLAMA

chatTest2LLAMA

testGianniLLAMA

testTastoInvioPreChanges

ChatTestPostPSWINVIO

SnapAdvisor

Current chat: debug0

Visualize references

Personal Advisor LLM

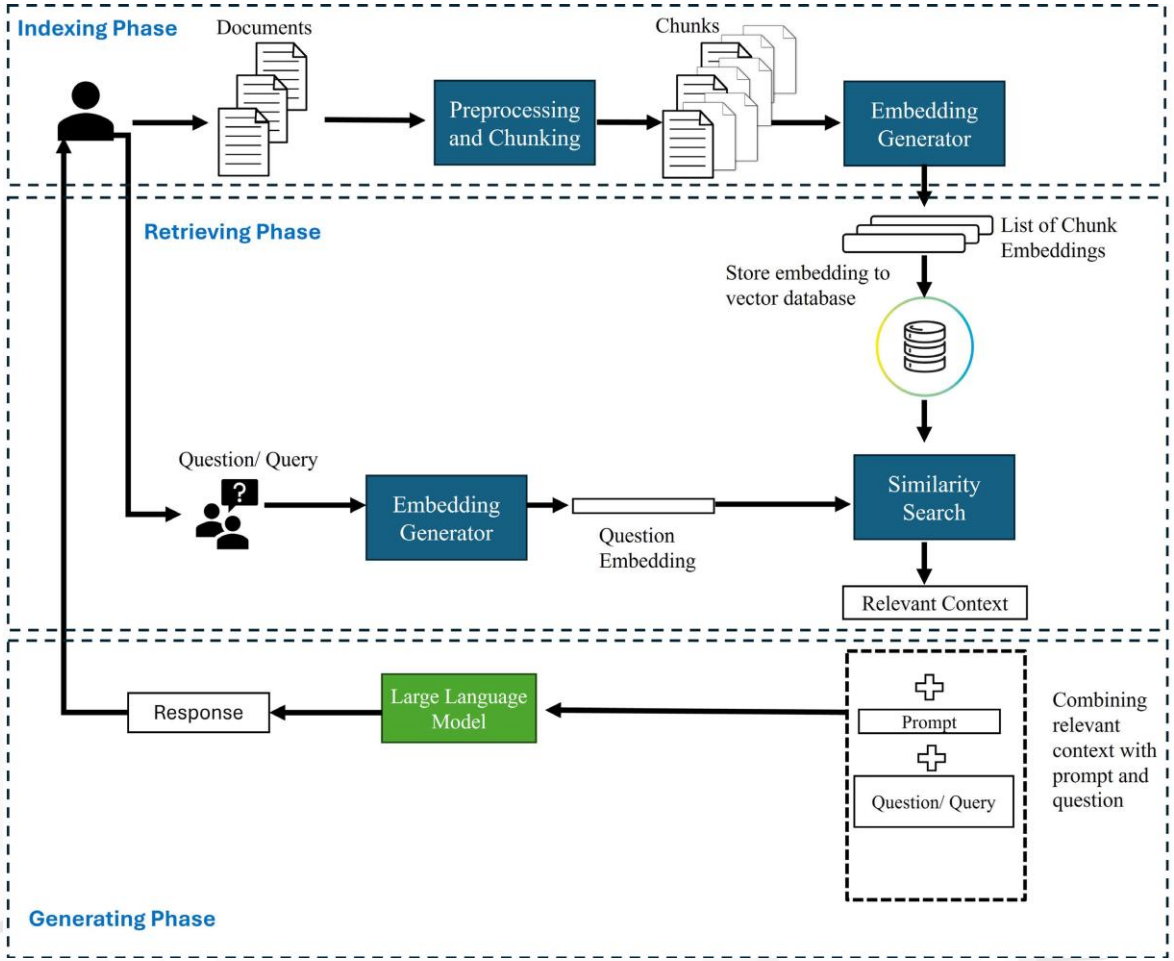
Come creo una dashboard?

Per creare una dashboard, puoi utilizzare la piattaforma Snap4City. La dashboard si compone di un insieme di widget grafici che possono essere impostati separatamente assegnando una serie di parametri, come origine dati, dimensioni, colori, forma, font, allarmi, relazioni con altri, ecc. (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Inoltre, la piattaforma offre la possibilità di creare vere e proprie applicazioni interattive, multipagina/multidashboard, e non semplici storie monopagina da scrollare. Puoi anche condividere la dashboard con altri utenti anche fuori dalla Smart City Control Room tramite canali autenticati e protetti in HTTPS, in accordo al GDPR (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Per vedere alcuni esempi di dashboard, puoi visitare il sito https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjU0Mg== (SOURCE: Snap4 City 1st Overview v4 8 annot). Tuttavia, non ho trovato informazioni dettagliate sulla procedura di creazione di una dashboard. Se hai bisogno di ulteriore assistenza, ti consiglio di contattare direttamente il team di supporto di Snap4City. Non so dirti altro in merito.

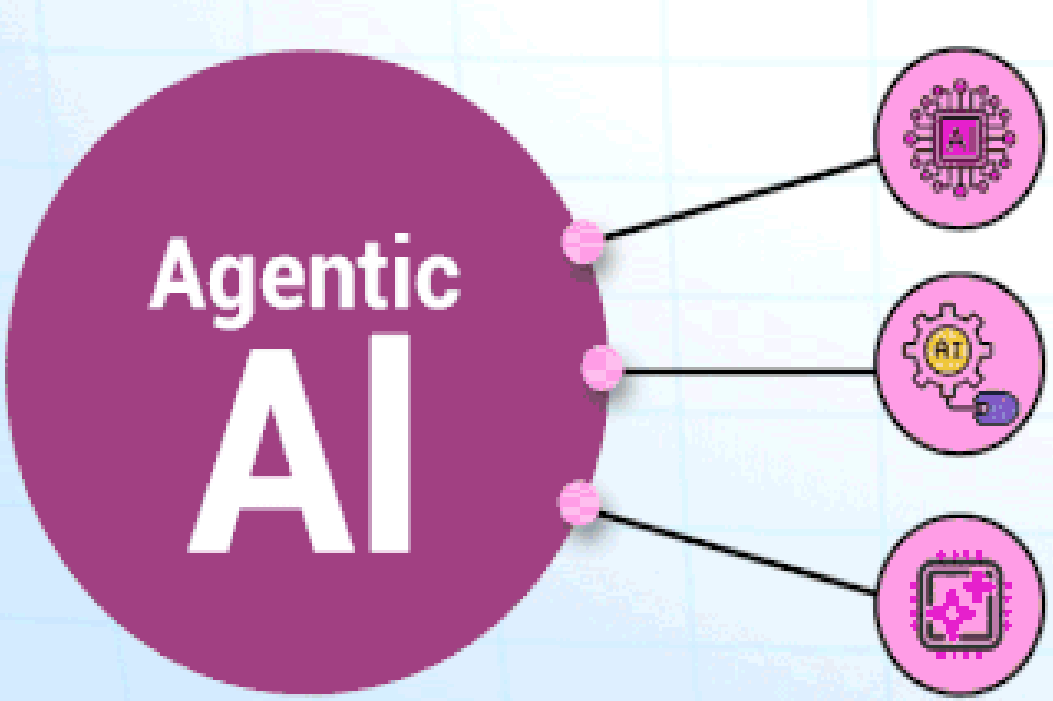
Write a message...

Retrieval Augmented Generation: RAG

- Approccio RAG:
  - Una base di conoscenza specifica viene suddivisa in frammenti (*chunks*), in genere consistenti dal punto di vista semantico (*semantic chunking*);
  - Per ogni chunk vengono generati i corrispondenti embeddings e indicizzati in un *Vector Database*;
  - **Retrieval**: viene generato l'embedding della domanda dell'utente (*query*) e viene fatta una ricerca di similarità nel Vector DB per recuperare i chunks più rilevanti rispetto alla domanda iniziale;
  - **Augmented Generation**: I chunks più rilevanti vengono inclusi come contesto insieme alla query iniziale (*augmented prompt*) ed inviati al LLM, che in questo modo è in grado di produrre una rispsota più accurata e centrata sulle parti rilevanti della base di conoscenza specifica.



The evolution is now: Agent/Agentic AI



7 AI Agents & Tool Use

- Create agents that execute tasks using APIs, tools, and external systems

8 Multi-Agent Orchestration

- Agents that work together, delegate tasks, and coordinate solutions

9 AI Product Integration

- Integrate AI into your products and services

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SNAP4CITY

KM 4 CITY

SnapAdvisor Copilot

Your AI-Powered Assistant for Smarter Cities

From questions to actionable insights — SnapAdvisor Copilot understands, plans, uses Snap4City services, and delivers results.

A Smart City Copilot with Agentic AI Capability

The evolution of the Snap4City digital twin, combining conversational/RAG assistance with AI agents that can plan, act, analyse and explain results in natural language.

How It Works

1. User request
Describe your objective in natural language

2. (Re)Planning
Interpret the goal and create a multi-step plan

3. Specialist agents
Select and invoke Snap4City services and APIs

4. Analyse & verify
Process results, recover from failures, and refine if needed

5. Answer
Deliver actionable insights in text, graphics and reports

Example Questions

- "What is happening in this area?"
- "Find the sensors/POI along this route."
- "Which route is better considering current conditions?"
- "Analyse these trends and predict what happens next."
- "What can be done to reduce the CO_2 emissions in Mercy road at 9:00?"

Wide Range of Capabilities

- Smart-city data
- Geospatial analysis & routing
- Statistics & analytics
- Prediction
- Spatial AI
- External information
- High level data management
- Reporting & multimedia
- Traffic and mobility
- Simulation & optimisation
- What-if / DSS
- Knowledge / RAG
- Action & interaction
- Visualisation 2D/3D
- Data generation

Key Benefits

No technical expertise needed
No need to understand APIs, data models or complex workflows.

Customisable & multilingual
Powered by RAG, with private knowledge collections.

Multi-domain knowledge
Mobility, energy, tourism, assets, GIS and more.

For everyone
Support for developers, operators, decision makers and more.

Proven Performance

90.5%	92.9%	86.6%	81.8
F1 for specialist-agent selection	Retrieval precision against SPARQL ground truth	F1 on 90 queries (4–8 reasoning steps)	G-Eval correctness (average)



One Conversational Interface. Multiple Smart City Capabilities.

Smarter questions. Brighter cities.

Agenda

- Laboratorio DISIT
- Tematiche del corso
- Infrastruttura del DISIT Lab
- Struttura del corso
- Modalità dell'esame

Big Data Architectures, 2025

- **Overview del corso e del Lab (queste slide)**
- **Cloud:**
  - virtualizzazione, HA, DRS, FT, architetture
- **Architetture**
  - Data Lake vs Data Warehouse
  - Batch and Data Stream processing:
  - IOT Architecture: AWS, Azure IOT, Google IOT,
  - Snap4City IOT/IOE, IOT Industry 4.0
- **Development Life Cyle for Big Architecture with AI**
  - Agile for Big Data Architectures
  - Containers: Docker, Kubernetes
  - MLOps, AI, ML
- **Analytics, AI, DL, RL, LLM**
  - Data Spaces of the European Commission
  - Mobility and Transport: traffic flow reconstruction, modeling, etc.
  - Big Data Analytics (base): Time Series, predictions, LLM, NeuroSymbolic
  - Visual Analytics: Business intelligence, Dashboard (esteso), Simulation, Agenti AI

Corso a 6 CFU

Storage Optional:

- *VIDEO: Indexing and Search: SOLR, SOLR Sharded, Elastic Search*
- *VIDEO: Big Data Storage Confronto: Hbase, Mongo*

Modello del Corso

- **Tipicamente per ogni argomento sono presentati:**
  - Requisiti e motivazioni dello sviluppo dell'argomento
    - Punto di vista dell'utente e del gestore
  - Stato dell'arte
    - Basi teoriche e tecnologiche, Eventuali standard
    - Prodotti di mercato (leader), pro e contro
  - Recenti Innovazioni e tendenze
  - Confronti fra le varie tecnologie e nuove soluzioni, pro e contro
  - Dettagli progettuali
  - Aspetti prestazionali e di scalabilità
- **Seminari di altri studenti e/o esperti, ….**

Ricevimento ed esame

- **Ricevimento per la didattica frontale**
  - Online:
    - Teams, cercatemi come: Paolo.nesi@unifi.it
  - In ufficio: Via S. Marta
    - Mandatemi una email: paolo.nesi@unifi.it
    - Tipicamente tutti i Venerdi dalle ore 11:00 alle 13:00

Agenda

- Laboratorio DISIT
- Tematiche del corso
- Infrastruttura del DISIT Lab
- Struttura del corso
- Modalità dell'esame



Superamento esame

- **Corso a 6 CFU**
  - **Modalita' per il superamento dell'esame: Orale**
    - **Chi preferisce puo' fare elaborato**
  - **Eventuale Project Work (PW) / Laboratorio per 3 CFU**
    - **Modalità per il superamento: discussione elaborato**
- **Corso a 9 CFU**
  - **Modalita' per il superamento dell'esame: solo elaborato**
- **Eventuali: PW, stage, tesi anche collegati fra loro**