SNAP4CITY

www.snap4city.org
www.snap4solutions.org

www.km4city.org

Smart Energy

Operation and Plan

Horizontal AI Platform

Tourism Management

Mobility and Transport

Smart Building

#snap4city
#km4city
#disitlab
@snap4city

Environment and Waste Management

01001001 1011
0111010 10010

City Users' Services

DIGITAL TWIN SOLUTIONS TO SETUP SUSTAINABLE DECISON SUPPORT SYSTEMS AND BUSINESS INTELLIGENCE

2025/26

www.snap4solutions.org

INTRODUCTION

Cities continuously adapts their services to address societal, environmental and economic needs and challenges. Verticals becoming obsolete are replaced by Artificial Intelligence enabled, AI, solutions to better exploit and common services. The lack of uniformity in the verticals created duplications of functionalities and thus higher costs and difficulties in maintenance, poor scalability. Multiple cities/areas require similar and tailored solutions, independent by sensor and sensor providers, thus opening the path for large regional platforms capable to scale on provide advanced innovations independently on sensor/device level.

Snap4City platform is a scalable solution from single city to regional coverage with multiple cities and areas. The platform is an advanced AI enabled 2D/3D Digital Twin, flexible, real time dynamic and highly interoperable with any device and protocol to increase sustainability and asset control according to city's operational objectives, and capable to support tactic and strategic plans (what-if, optimized and simulated) fully integrated with the territory and stakeholders. **Snap4City exploits** any data/device (**GIS, IoT, BIM, ITS, Sat., OSM, ODM, NGSI, MQTT, CKAN, OGC, OPC-UA, ModBUS, etc.**) to get info and act, and provide hints and controls with respect to the AI Digital Twins of the services of the city/area, providing to decision makers easy to grasp explanations of suggestions (proposed solutions) via eXplainable AI, XAI, and AI-Ethics, and grounded on KPI. In operation, Snap4City produces real time notifications (early warning) on multiple channels, and may also perform actions according to profiling and any KPI: decongestion, increment of service quality, reduction of emissions, reduction of costs, etc. (SUMI, SUMP, DUT, SDG, 15MinCityIndex, etc.)

Snap4City provides a set of ready to use tools on multiple domains of the city/area to perform real time operation and/or planning, on: **mobility and transport, energy/light, waste, environmental, government, tourism, security, safety, civil engineering**. The most widely adopted smart tools and dashboards grounded on KPI cover **Control Rooms, Smart Parking, Fines Management, Asset Management, Smart Light, Smart Waste, Traffic and Mobility services optimisation, Tourism management and Optimisation**. As it is on more than 45 cities/areas in countries as Italy, Cyprus, Spain, France, Bosnia-Herzegovina, Greece, Croatia, Sweden, Belgium, Australia, Brazil, China, Romania, Malta, etc., as well-known cities of Florence, Valencia, Merano, Malta, Limassol, Varna, Cuneo, etc. **Snap4City is the reference platform** of Sustainable Mobility Center in Italy (CN MOST), CN HPC big data and quantum computing in Italy, Smart Cyprus, Rhodes's control room, in progress with ISPRA JRC SOC, etc. A number of Living Labs adopted Snap4City solution: Florence, Rhodes, CN MOST, etc.

Any Snap4City platform is provided with its main integrated development platform based on Node-RED, JavaScript. A number of solutions for computing and rendering on integrated graphics and for generating predictions, heatmaps, ODM, scenarios, synoptics, maps, 2D/3D, animations, etc., are provided in open source in basic installations or a simple addon. **Advanced Snap4City AI toolbox includes a set of ready to use modules** based on ML, AI, Generative AI, LLM, RAG LLM, Deep NN, etc., are: *statistics, advanced predictions, early warning, advanced heatmaps, classification, suggestions, simulations, sentiment analysis, optimisation, routing, zoning, reconstruction, origin destination matrices, trajectories, LLM via Snap4Advisor, etc.*, by which any smart and business intelligence tool can be created.

Developers of Snap4City may request access to SnapAdvisor which is a Generative AI expert of Snap4City platform which provides answer about how to develop new solutions based on Snap4City tools and help in using standard Snap4City applications and framework. SnapAdvisor is based on a Generative AI LLM. A custom SnapAdvisor can be provided for large Snap4City platforms to assist operators and decision makers on data dependent specific context.

Snap4City is a 100% open-source platform which provides fast and easy start up (on public and private clouds) thanks to its interoperability and automated installation tools. Snap4City is semantically interoperable with Km4City ontology (https://www.km4city.org) grounded on SAREF/S4CITY, WGS84, OTN, DCterms, GTFS, OWL-Time, FOAF, BOT, SSN, etc., is an official FIWARE Platform (https://www.snap4city.org/467, https://www.fiware.org/), compliant with FIWARE Smart Data Models, IoT Data Models, Data Spaces, and a large range of High-Level Types, official EOSC (European Open Science Cloud) Platform, official Node-RED Library, official E015 API, etc. Snap4City is provided "as a Service" or installed on premise, as well as on pub cloud as AWS, MS-Azure, ARUBA, etc., no licence fee is needed. The list of public **Snap4City installations** is accessible on web portal.

Cybersecurity and Privacy: Snap4City is GDPR (General Data Protection Regulation of Europe Union) compliant, and passed **PEN-Test**. With Snap4City you can create your certified entities/data, and sequences of events using the provided Blockchain support. End-2-end secure connections are established from devices to dashboards, web user interfaces, including data processing, storage and data analytics: https://www.snap4city.org/549. Snap4City is compliant with OpenID Connect, SSO, OIDC, SAML/IAM, European Identity Card, SPID, EU Login, Active Directory, etc. The platform is provided with its **Snap4City Sentinel** application to monitor 24/7 all the functionalities and report any kind of problem over multiple channels.

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THE SOLUTION AND VERTICALS

Snap4City platform can cope with any data and information covering **multiple domains / scenarios** (https://www.snap4city.org/4) in integrated Digital Twins, coverage for requirements of MIM Plus, ENOLL, LDT, CitiVerse, e providing functionalities for operational management, simulation, what-if analysis, optimization and plan:

- **Mobility and transport solutions and applications:**
  - **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), dynamic routing, multimodal routing, city user behaviour analysis.
  - **Optimization and what-if analysis:** traffic light plans, traffic infrastructure. Reduction of: travel time, waiting time, # stops, CO_2 emissions, consume fuel, travel time for tramways and busses.
  - **Public Transport:** Analysis of Mobility Demand vs Offer of Transportation (DORAM2).
  - **Parking Management:** monitoring, prediction, any payments, on-road/off-road.
  - **Sharing / Pooling Management:** eShare and mobile app, bike-sharing, smart bike, fleet management.
  - **KPI:** SUMI/SUMP, travel time, emissions, traffic status, accessibility, ..
  - **Mobile App:** final users and operators: Info Mobility, traffic, parking, payment, fine management, city user participation, charging, overparking, …

- **Energy, eVehicles and Building's solutions and applications:**
  - **Goals:** Energy consumption reduction; increment of efficiency; areas and building sustainability; improve accessibility to services, security and safety.
  - **Energy Monitoring:** Building, floors, rooms, recharging poles, cabinets, Community of Energy, data centres, energy for hot / cold, air condition, energy vs temperature and usage, etc.
  - **Energy Management:** Predictions, early warning, identification of critical conditions.
  - **Smart Light Management:** LED/mixt, cabinets; lights control vs traffic, lights vs security, energy saving, luminaries profiling, group management, ...
  - **Smart Building Management:** consumptions, number of people, communities of energy, photovoltaic plants, sustainability, ..
  - **KPI:** Energy consumption, efficiency; light profiling and adaptation; autoclave industrial plants optimisation, photovoltaic plant simulation; consumption / usage, energy vs temperature, ...
  - **Mobile App:** monitoring, info-recharge, eSharing, booking, ...

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- **Tourism, city users' behaviour, services solutions and applications:**
  - **Goals**: improve Quality of Life and quality of services; Over tourism mitigation, sustainability; Costs reduction of services; Improve accessibility to services: citizens, tourists, commuters, etc.; Improve Security/Safety of city users.
  - **People Flow Analysis / Management:** in/out-door, retail, attractions: counting, tracking, flows, origin destination matrices, sentiment, recency/frequency, etc.;
    - Multiple sources: thermal & TV cameras, radar sensors, PAX sniffers, mobile data, Wi-Fi, traffic data, mobile phone data, card data, etc.
    - Suggestions: info Tourism, digital signages, engagement, ...
  - **Tourists Flows & Retail Management:** predictions of presences, services' reputations, suggestions on second offer, over-tourism mitigation, notifications, early warning,
  - **KPI:** 15 MinCityIndex, energy vs people, over-tourism, accepted suggestions, precision.
  - **Mobile App:** final users services/informing and operators; Info Tourism, people flows, info mobility, sharing, participation, engagement, ...

- **Environment and Waste Management solutions and applications:**
  - **Goals:** reduction of emissions and EC taxations; cost reduction for waste collection; reduction of waste collection impact on mobility.
  - **AIR quality (Indexes) monitoring and warning:** heatmap, notifications, early warning.
  - **Environment Management producing prescriptions:** monitoring, long/short-term predictions, early warning: GHG, emissions, pollutants, aerosol, chemical plants analysis, coastal erosion (blue economy); Traffic Flow impact emissions, predictions.
  - **Land slides predictions/warning.**
  - **Waste Management and Optimisation:** costs reduction, optimal routing production, pay as you throw, avoiding out of bins, predictions of waste production on bins, alarms.
  - **KPI:** SDG, 15MinCityIndex, QOS, costs, Km, collecting time, EC KPI, emissions.
  - **Mobile App:** final users services/informing and operators, Info Waste for operators, participation, optimal routing, WEEE Collection, ...
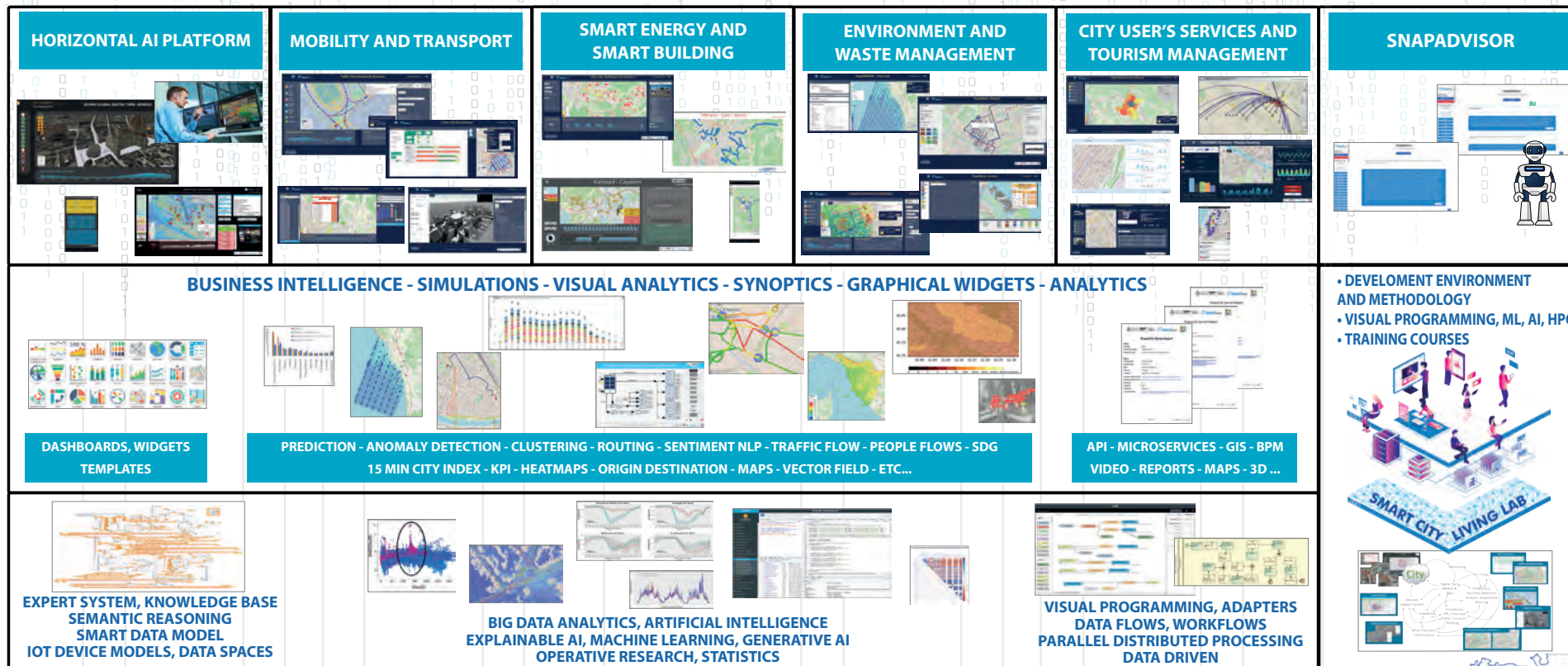
- **Horizontal Platform, a decision support system, which may integrate all the above plus: governance, security, asset management, solutions and applications**
  - **Goals:** Increase quality of Life, quality of services; Decongestion, Decarbonization, Sustainability; increase efficiency and production optimisation; Improve accessibility to services: citizens, Tourists, commuters, etc.; Improve security/Safety of city users, risk reduction; Costs reduction of services, energy consumption reduction; Reduction of emissions and EC taxations.
  - Horizontal homogeneous platform Uniform Technology for
    - **Any Vertical operation/plan:** mobility, energy, environment, security, tourism, infrastructure and assets control, buildings, etc.
    - **Asset Control:** ICT devices, TV Cams, energy consumption, productivity, Hosts, VM, clusters, traffic gates, UPS, etc.
    - **AI Solutions:** early warning, predictions, simulation, what-if, optimisation;
      - Deep Learning, ML, BERT, LLM, XAI (Shap/Lime), etc.
      - Simulations: SUMO, DORAM, Routing, TFR, Flooding, people flow, etc.
    - **Development Environment for any vertical, Digital Twin:** City Global and Local, IoT, VR, Visual Programming, business intelligence, CSBL, SSBL, Blockchain, etc.
    - **Interoperability:** any format, any protocol, any video management system, any sensor, any device, etc.
  - **KPI:** multidomain KPI, general management, early warning, early detection of critical conditions, 15MinCityIndex, SDG, etc.
  - **Mobile App:** modular applications, operators' modules, multiple cities, etc.

- **Industry 4.0**: depuration plants, production plants (monitoring industry plant, control and optimization, digital twin), production plant, predictive maintenance, integrated life cycles among different industry plant, such as on ALTAIR chemical plant, marketing analysis, production of suggestions and engagements; https://www.snap4city.org/369.

Interoperability: IIn the large range of smart city solutions, Snap4City is compliant with more than 190 protocols and formats, and it capable to fully interoperate and/or integrate any other system/application. It is highly interoperable with any GIS, BIM, CKAN, Satellite Services, OSM, GTFS/NeTex, MQTT, NGSI, SAML, OPC, OGC, OSM, transport protocols, and IoT Networks protocols (IoT protocols), WoT, smart data models, Data Spaces, services and databases: https://www.snap4city.org/283, https://www.snap4city.org/65. Snap4City is an official FIWARE platform, exploits FIWARE multi-tenant Context Broker, NGSI-V2/LD protocols, Smart Data Models, automated broker deploys, protected communications and multiple broker connections/protocols. The interoperability, flexibility and modularity of Snap4City together enable the creation of business intelligence applications in a wide range of scenarios and domains. Snap4City enables the creation of federations of Smart City solutions via Smart City API. Snap4City APIs are REST CALL accessible and well documented for developers, allowing customization, usage and development of mobile and web Apps, and with your legacy solutions.

Data Integration, ingestion and distribution: Snap4City provides effective and simple to use tools and solutions for fast data ingestion and aggregation exploiting a large range of protocols and standards, and supporting any. Snap4City provides a large range of ready to use connectors (event driven, real time, push/pull) and High Level Types models for shortening the processes for manipulating simple and complex data such as *POI, KPI, IoT Devices/entities, Satellite, Digital Twins, BIM, OD Matrices, Traffic Flows, Heatmaps, 3D Shapes/patterns, Typical Time Trends, Color Maps, Trajectories, Flows, Video Streams, TV Cams, CAP events, Routings, User profiles, Digital Terrains, Maps, Orthomaps, SVG graphics, synoptics, City Scenarios, Vector Fields, public transport services (GTFS, NeTEx), 3D buildings, Fines, Payment Profiles, Payment Policies, user profiles, annotations on floors, Floors, etc.*

UNIVERSITÀ DEGLI STUDI FIRENZE | **DINFO** DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | **DISIT** DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB | **SNAP4CITY** | **KM4CITY**

THE POWER OF ARTIFICIAL INTELLIGENCE AT THE SERVICE OF YOUR OPERATION AND PLAN

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

| HORIZONTAL AI PLATFORM | MOBILITY AND TRANSPORT | SMART ENERGY AND SMART BUILDING | ENVIRONMENT AND WASTE MANAGEMENT | CITY USER'S SERVICES AND TOURISM MANAGEMENT | SNAPADVISOR |

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

DASHBOARDS, WIDGETS TEMPLATES

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

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

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

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

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

- **DEVELEMENT ENVIRONMENT AND METHODOLOGY**
- **VISUAL PROGRAMMING, ML, AI, HPC**
- **TRAINING COURSES**

SMART CITY LIVING LAB

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

INDUSTRY4.0 · SHARING · PARKING · LIGHT · AGRICOLTURE · ENVIRONMENT · ENERGY · SHOPPING · MOBILE · WASTE · SECURITY · CONTROL ROOM · BUILDING · SATELLITE · TRANSPORT · TOURISM

NATIVE AND EXTERNAL APPLICATIONS

| Smart Parking |
| Smart Light |
| Smart Waste |
| Smart Energy |
| Smart Building |
| Smart Tourism |
| ... |

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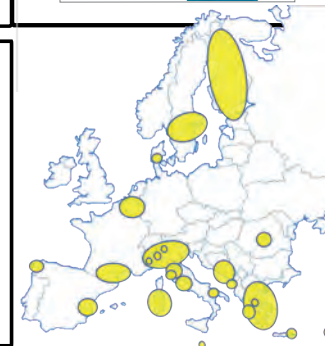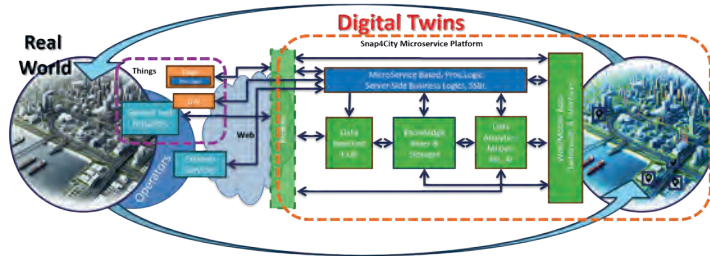
DIGITAL TWIN, CITIVERSE, EMBEDDED

Snap4City solutions models entities as a Digital Twins, including spatial, temporal, relational aspects of any city element and data, 2D/3D geometries and patterns, plus behavioural aspects associated with the entities including dynamics, simulations, predictions, optimisations, etc.; actionable elements; KPI/metrics of any sort, business models and business intelligence tools. Artificial Intelligence and simulations are used for computing predictions, generating solutions and suggestions, proposing plans to make decisions and to perform what-if analysis and optimisations also with reinforced learning and generative AI. Snap4City manages both open and private data, static and real time event driven data of any domain and organization. Snap4City supports all the advanced solutions for:

- **A large range of Applications** providing business intelligence, visual analytics, AI support, optimisation, KPI, such as those listed in the previous section.
- **Dashboards and control room applications** with business intelligence and logic.
- **Artificial Intelligence based tools** running on NVIDIA and CPU/GPU clusters, and when needed also on HPC, as well as on cloud servers in Python, Rstudio and other languages. They can be developed or integrated by following a MLOps for scalable solutions.
- Digital Twin Global representing and navigating the city in 3D/2D on Web Browser, with shapes of the building, facades, roofs, high value buildings, BIM details for buildings, heatmaps and animations, traffic flows, pins,

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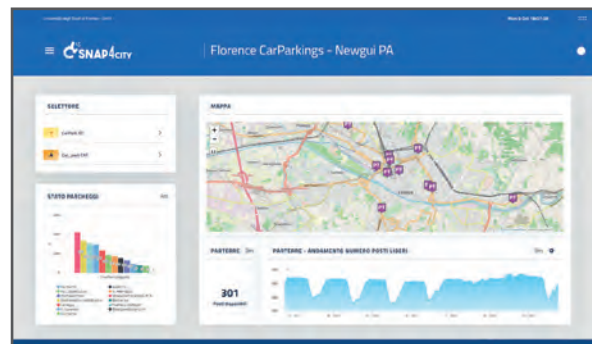
devices, POI, KPI, furniture (trees, luminaries, busses, aircraft, cars, benches, etc.), flooding, etc. https://digitaltwin.snap4city.org

- **Digital Twin Local** representing 3D shapes of building, BIM, internal floors and external navigation, association of 3D elements to devices, IoT real time data, etc., also with the possibility to perform measures on maps and floors. https://www.snap4city.org/716
- **CitiVerse** with walkable 3D representations and tools on Ureal and Oculus, exploiting the same real time data of Local and Global Digital Twins.
- **Mobile Applications** for mobility and transport, parking,

sharing, environment, participation, optimized waste collection, fines management, etc.

- **Edge solutions** supporting the installation of Snap4City processes and interfaces in local / embedded systems, robots, devices, TV cams (Linux, Windows, Arm, Raspberry Pi, Android, etc.). They can be on Node-RED as well as other formats for logic. Secure connection with the platform. They can be on Node-RED as well as other formats for logic.
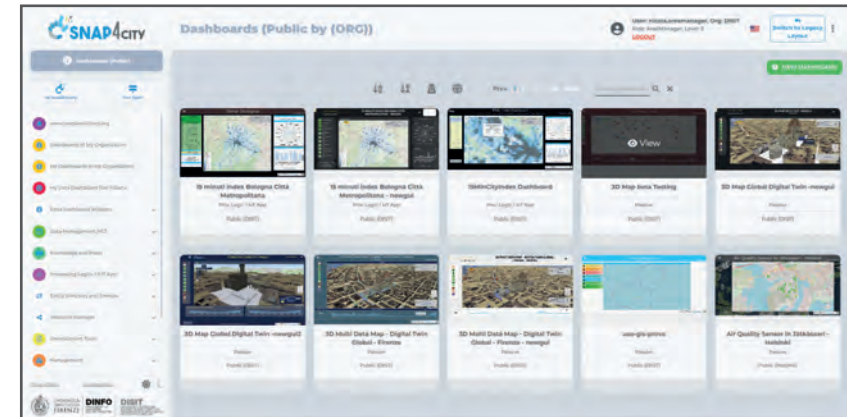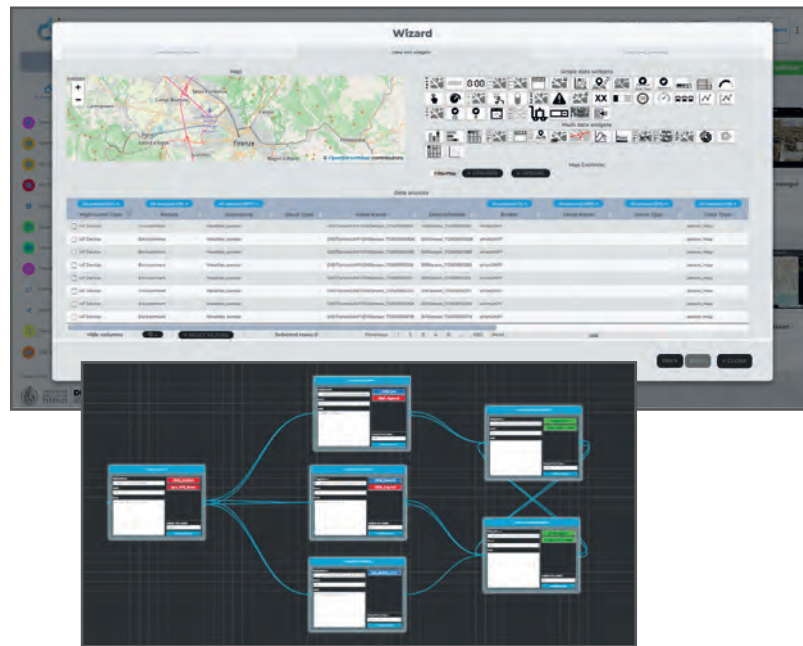
Snap4City Verticals, Applications, and Dashboards are based on Dashboard Builder and its Snap4City intelligence engine provides a wide range of AI functionalities to produce data hints (http://www.snap4city.org/997) including SnapAdvisor Generative AI, and interactively play with any variety of complex data via powerful graphic representations: *maps, orthomaps, tables, time trends, heatmaps, heatmap sequences/ animations, traffic flows and animations, origin destination matrices and animations, typical trends, calendar heatmaps, Kiviat / spider, hierarchies, sunburst, bubbles, scatterplot, tree maps, Ven circle packing, chords, stream graphs, radial, barseries, custom widgets, SVG animations, what-if scenarios, routing, multimodal routing, public transport time line, weather forecast, BIMs, buttons, 3D shapes on local (building) and global Digital Twins (for the whole city), synoptics of any kind, dynamic / graphics PIN on maps, trajectories, generative AI scenarios, payment profiles, fines, vector fields, public transport services, etc.*

MAIN SOLUTIONS

● **TRAFFIC OPTIMIZATION**
https://www.snap4city.org/1014

● **TRAFFIC LIGHT PLANNING**
https://www.snap4city.org/1015

● **3D DIGITAL TWIN**
https://www.snap4city.org/749

● **PARKING MANAGEMENT**
https://www.snap4city.org/1013

● **SMART LIGHT MANAGEMENT**
https://www.snap4city.org/968

● **CITY USERS' ENGAGEMENT**
https://www.snap4city.org/1018

● **SECURITY MANAGEMENT**
https://www.snap4city.org/966

● **SNAPADVISOR**
https://www.snap4city.org/1116

● **BUILDING MANAGEMENT**
https://www.snap4city.org/970

● **ENVIRONMENT CONTROL**
https://www.snap4city.org/1037

● **WASTE MANAGEMENT**
https://www.snap4city.org/982

● **15MIN CITY INDEX**
https://www.snap4city.org/652

● **CAR SHARING/POOLING**
https://www.snap4city.org/1004

● **ENERGY MANAGEMENT**
https://www.snap4city.org/1038

● **TOURISM MANAGEMENT**
https://www.snap4city.org/1017

● **ADVANCED ROUTING**
https://www.snap4city.org/1106

● **SIMULATION SUPPORT**
https://www.snap4city.org/1121

DATA TYPE COVERAGE

- **POI, IOT Devices, shapes, ...**
  - **FIWARE Smart Data Models**
  - **IoT Device Models**
- **GIS, maps, orthomaps, WFS/WMS,**
- **GeoTiff, calibrated heatmaps, ..**
- **Traffic flow, typical trends, ..**
- **Public Transport Services,....**
- **3D Models, BIM, planimetries, ...**
- **2D/3D Digital Twins, ..**
- **OD Matrices of several kinds, ..**
- **Vector Fields**
- **KPI, personal KPI,..**
- **Satellite data, microsatellite, ..**
- **Synoptics, animations, ..**
- **trajectories, events, Workflow, ..**
- **Dynamic icons/pins, ..**
- **Social media data, TV Stream,**
- **Routing, multimodal, constraints, ..**
- **City area scenarios, ...**
- **Measures on floors and maps**
- **etc.**

- **SCENARIOUS**
  https://www.snap4city.org/4

- **ORGANIZATIONS**
  https://www.snap4city.org/download/video/cov/

- **INTEROPERABILITY**
  https://www.snap4city.org/65

- **APPLICATIONS / PROCESSING**
  https://www.snap4city.org/997

- **HOW TO INSTALL**
  https://www.snap4city.org/738

- **CLIENT SIDE BUSINESS LOGIC**
  https://www.snap4city.org/911

- **DIGITAL TWIN**
  https://digitaltwin.snap4city.org/

- **LATEST NEWS**
  https://www.snap4city.org/135

- **ARTIFICIAL INTELLIGENCE**
  https://www.snap4city.org/524

- **ARTICLES**
  https://www.snap4city.org/78

- **SNAP4INDUSTRY**
  https://www.snap4industry.org

- **SIMULATORS**
  https://www.snap4city.org/1053

- **DEVELOPMENT LIFE CYCLE**
  https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf
  https://www.snap4city.org/download/video/ClientSideBusinessLogic-WidgetManual.pdf
  https://www.snap4city.org/91

- **TECHNICAL OVERVIEW**
  https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf

- **SNAP4CITY FIWARE IMPACT STORY**
  https://www.snap4city.org/drupal/sites/default/files/files/FF_ImpactStories_Snap4City.pdf

SNAP4CITY ADVANCED DATA PROCESSING AND DEVELOPMENT

MOBILITY4FUTURE

MERANO

Traffic Flow Analysis By Scenario

VENARIA REALE

Monitoring Cross Road Venaria - (AXIS Camera)

Snap4City provides horizontal and/or vertical applications and solutions. In any deploy of Snap4City also the development environment is provided which can be used to develop data ingestion processes, views and applications, as an almost no-coding platform. List of public Snap4City installations is accessible: https://www.snap4city.org/661

Any Snap4City capabilities can be tested from: https://www.snap4city.org (free registration on DISIT Organization).

Snap4City provides easy to use tools for customizing and creating applications with multiple views, dashboards and tools, up to complex vertical applications with business intelligence and AI. On Snap4City platforms, you can register entity models, create devices, create Dashboards/views, create data processing and business intelligence tools by using visual programming, and also artificial intelligence processes. **Snap4City Dashboard/View Builder** with its **Wizard** is shortening the complex production of any user **Dashboard/View** exploiting data creating your own business intelligence custom tool in a few passages by compounding in visual manner the above-mentioned graphics features with your data. The Knowledge Base (Km4City ontology and LD, linked data) provides support for semantic and real time queries.

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Data Inspectors help the developers to identify data and see their metadata and twin data. Snap4City provides **data processing tools** based on visual programming Node-RED of JS Foundation in which the open **Node-RED Snap4City Libraries** provide a large set of MicroServices for creating data adapters, integration, interoperability, business logic and data transformations. They can be also easily used to compute KPIs and real time indicators needed by cities such as, SDG indexes, EC indicator on pollutants (ISO37120, 37122); 15MinCityIndexe; SUMI; SUMP; etc., and to assess event driven critical conditions. Node-RED is used for **visual programming** of any data ingestion and transformation so that the city operators with Snap4City can actually create and customize any **smart applications** in visual manner and short time. **A free full training course is provided**: https://www.snap4city.org/944

Snap4City fully supports the development of **Artificial Intelligence**, ethic explainable artificial intelligent (XAI) via languages such as Python, Java, R-Studio, also exploiting Tensor Flow, Pandas, Keras, BERT, LLM, and any kind of library for AI, machine learning, deep learning, fine tuning, transfer learning, etc. Large scale AI development environment include MLOps facilities and clusters of GPU/CPU and HPC such as on Snap4City.org and for CN MOST. Large number of AI solutions is accessible: https://www.snap4city.org/997

Snap4City is distributing AI tools and algorithms for: prediction, anomaly detection, heatmap production, clustering, classification, match demand vs offers of transportation, and many others for implementing: Smart Parking, Smart Biking, traffic flow reconstruction, traffic flow prediction, land slide predictions, retail suggestions, NOX prediction, NO2 prediction, CO2 computing, people flow analysis, public transportation analysis, routing, etc. Data Analytics is fully integrated into **What-If analysis and Optimisation tools** in control rooms and for operators, defining scenarios and solutions. Snap4City is integrated with **SUMO** for simulation, other simulations are provided by Snap4City. Other integrated tools with Snap4City are: OSM, VMS Milestone, Graphhopper routing, CKAN, Brokers, Node-RED, Cultron debug Node-RED, ClearML MLOps, ArcGIS, QGIS, Copernico, GeoServer, D3 library, NeTex, LOGraph, Jasper report, OpenMaint, BIM server, flooding, etc.

BENEFITS AND IMPACT
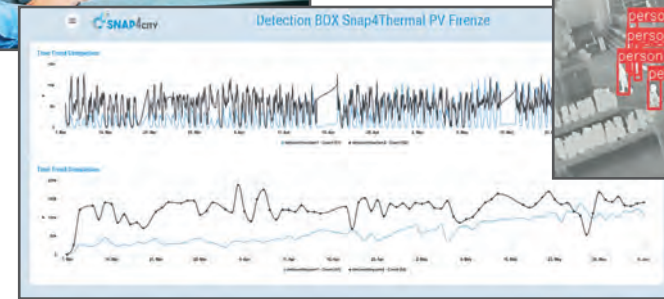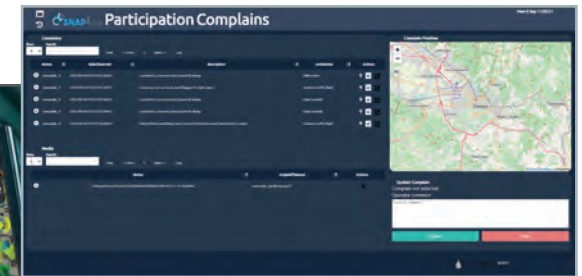
Snap4City has brought great benefits where it has been adopted for operational management, prediction, and plans. The low costs for its adoption and usage allowed many adopters to add functionalities and widely exploit the visual tools.

In **Merano**, a Snap4City platform on premise controls the **SmartLight** according to the standards and successfully manage the light profiling in multiple zones, also where a mixt of led and traditional luminaries and cabinets are installed. **Benefits**: reduction of energy costs, reduction of personnel costs for managing transition, increment of reliability. https://www.snap4city.org/1023

In **Cuneo**, a Snap4City platform on premise **monitor and control ICT assets** (switched, APC, TV Cameras) and **security** also counting people and detecting critical cases via thermal camera with Snap4City AI Plugin detecting problems and notifying events in real time. **Benefits**: reduction of costs, reduction of personnel costs for operation, increment of reliability. https://www.snap4city.org/975

In **Rhodes**, a Snap4City platform on premise, set up in collaboration with UNISYSTEMS, provide support for the **control room and for a number of applications** developed by multiple vendors of the area. **Benefits**: reduction of costs, increment of services and quality of life. https://www.snap4city.org/1052

For **CN MOST** (National Center on Sustainable Mobility in Italy), a Snap4City **national platform** named **Mobility4Future provides solutions as a service for small and medium cities** regarding operation and plan for the reduction of congestion and emissions. To this purpose a number of AI tools of Snap4 are disposal of the cities such as: advanced routing, road infrastructure optimisation, traffic monitoring, simulation of traffic conditions, match demand and offers of public transportation, computation of SUMI, etc. See flagship actions as OPTIFaaS, LeverageOPTIFaaS, SASUAM. **Benefits**: reduction of congestion and emissions, reduction of costs for mobility planning, reduction of costs for KPI computing. https://www.snap4city.org/1008

MOBILITY4FUTURE
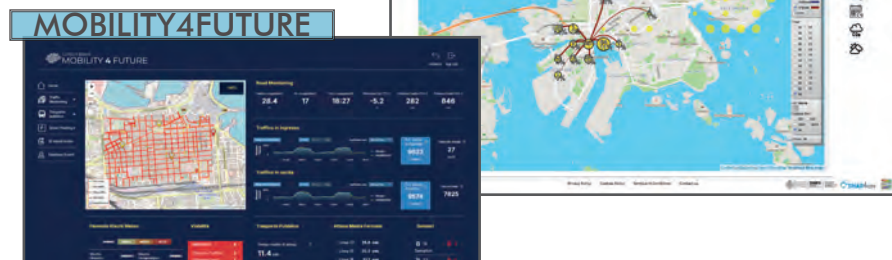
In **Florence, Valencia, Varna, Malta, Limassol, Rhodes, and Bisevo**, Snap4City.org provides service for monitoring and managing tourism flows in the areas and on major attractions. Services include dashboard and AI tools for: monitoring people counting and flow, analysing questionnaires with LLM and producing suggestions, producing forecasts, providing info Tourism in real time, assessing environmental conditions, computing people flows and ODM, etc. Multiple kind of sensors, cameras, drones, and sniffers are used for the purpose with AI and LLM **(SnapAdvisor). Benefits**: reduction of services congestion, enabling data driven decisions, better distribution of tourists, increment of resilience and fastening the problem detection. Similar action has been done in Dubrovnik, Mostar, Pont Du Guard, etc. https://www.snap4city.org/1001

In **Cyprus**, Snap4City has been selected as the reference platform for the deploy of Smart Cyprus in the whole island for providing smart waste, smart parking and for monitoring and supervising smart light in multiple cities.

Several other installations and services have been performed in multiple cities and areas. See for a large list and for updates: https://www.snap4city.org/4 and/or https://www.snap4city.org/download/video/cov/, installed Snap4City platforms https://www.snap4city.org/661

Snap4City has been adopted in a number of European, national and regional actions and projects: TOURISMO Interreg, AMMIRARE Interreg, ELLIE Horizon Europe, Tuscany X.0 EDIH, CAI4DSA of FAIR PE (national project on Artificial Intelligence for society), CN HPC big data and quantum computing (DI-DTPlatform, UrbanDR4TF), SMART3R-FLITS, SADI-MIAC, REPLICATE lighthouse H2020, RESOLUTE H2020, TRAFAIR CEF, Sii-Mobility MIUR, SODA4.0 of ALTAIR, 5G MIUR, MOBIMART Interreg, HERIT-DATA Interreg lighthouse, Life Weee, IMPETUS, MOSAIC, AMPERE, Enterprise, PANACEA, ALMAFLUIDA, Energia, BullVIT, The, Masterpiece, and PC4City, etc. These actions have involved a large number of partners from private industries and public institutions (cities, regions, universities, foundations) working and using Snap4City platform. For most of them, a dedicated web page is provided on main platform, see the news on these issues on https://www.snap4city.org/135 Moreover, since a number of years Snap4City platform is on progressive adoption of the SOC of ISPRA JRC of the European Commission.

Awards: DISIT lab started the Snap4City line since 2013 with the first data integration for Florence city, and in the 2019, turned out to be the winner of the Select4Cities PCP of EU managed by Antwerp, Helsinki and Copenhagen, one year later won the ENEL-X open data challenge in 2020. Also, Herit-Data action with Snap4City platform received the Lighthouse flag from the European Commission. Currently, Snap4City is one of the platforms of the EOSC (European Open Science Cloud), library of Node-RED, CN MOST, CN HPC big data and quantum computing, etc., and DISIT Lab is a Gold Member of FIWARE and an official FIWARE Platform and Solution, certified Consultant, certified Trainer, provides two certified FIWARE Experts; member if GAIA-X; and recent best awards for Digital Twin platform for Smart Cities from DMS, and ICCSA communities, and from the observatory of Digital Twins of FBK and IFAB in the context of CN HPC big data and quantum computing.

GET STARTED WITH SNAP4CITY FOR CITIES AND INTEGRATORS

Trial is open on Snap4City.org portal via a free registration, please select DISIT Organization for a larger set of data and tools. https://www.snap4city.org/drupal/user/register

Snap4City for dummies: https://www.snap4city.org/1046

Snap4City provides a set of standard configurations directly downloadable from web, from small standalone solutions to very large scalable installations. **Snap4City multitenant multidomain modular platform based on microservices** can be installed on-cloud, on-premises and on hybrid solutions; via VM, dockers and Kubernetes, on AWS, Ms-Azure, etc. - all modules are licence free. An easy tool to get container-based installations accessible: https://www.snap4city.org/738. Typically, one start small (e.g., Micro X) to progressively extended storage and redundance with procedures. Snap4City installations may be endowed by **Snap4City Sentinel** which is dedicated tool for H24/7 supervision and control. Snap4City is distributed open source (Affero GPL) including the application layers. Snap4City provides all needed tools for managing: data, users, organizations/multitenant, resource, accounting, processes, auditing, high level types, reporting, multilingual, menu configuration, scheduling, alerting, quality control, data inspection, reporting, view, verticals, applications, mobile applications, etc. The deploy of Snap4City includes also supports for: Digital Twin, smart application, dashboard control and usage, business intelligence, etc. Specific modules have to be adopted to add Artificial Intelligence engines, which can be also scalable and can be progressively added and extended. **Integrators and adopters** can access to the catalogue of modules and services to compose their preferred version of Snap4City platforms.

Snap4City platform can be adopted by requesting to us the installation on your premise on public/private cloud or requesting a solution "as a service" from our or other public cloud, all done in less than 60 days. Book for a call via email: snap4city@disit.org typically to identify as starting point 1-3 domains/verticals, some data sources (legacy or new), 1-2 applications.

We can customize your Snap4City instance, integrate your legacies or preferred third party modules of any kind (they can be open source or proprietary). We provide H24 help-desk, maintenance according to consolidated SLA and/or second/third level maintenance for distributors and integrators worldwide. All the installed versions of Snap4City includes also the main development environment which allows you to develop data processes and dashboards. For the list of installed platforms see: https://www.snap4city.org/661 which use the **Powered by Snap4Tech** logo in their installations.

Training: Snap4City community of developers and users is a source of stimulus and innovations. Snap4City provides an open, free of charge and comprehensive training course and on-line development open platform for testing and using the solution. The course is provided on slides, interactive slides and videos, and includes case studies from: https://www.snap4city.org/944. In most cases, for stimulating a larger local collaboration of stakeholder, hackathons have been launched.

Special program for research institutions: Research no-for-profit institutions or foundations can set up agreement with DISIT Lab for exchanging researchers and/or becoming experts lab of Snap4City in your area. A setup support is provided free of charge to help them starting using the platform. The results produced are promoted by Snap4City according to different channels including the Snap4City users' network and mailing lists.

Snap4City provides a support for setting up Living Labs. The largest is on Snap4City.org. A consolidated methodology based on quadruple helix helps you setting up your smart city engaging stakeholders and final users.

TECHNICAL ARCHITECTURE

Any API

Data Ingestion

Entity Directory:
Smart Data Models
IoT Data Models
Digital Twins

FIWARE

Brokers
MQTT
Brokers

Brokers

Social Media
OSM, BIM, GIS, ITS
Gateways, Satellite
External Services
Web Scaping
TC CAM Streams

Node-RED

IoT App ProcLogic

IoT App ProcLogic

Storage and Processing

API Manager

Federation Smart City API

OpenSearch
virtuoso

Storage

KB, graph

Entity Inspector

Data Manager

HLT Manager

Service Map

GeoServer

BIMserver.center

Simulators' Tools:
SUMO, DORAM, TFR, ...

python R Studio

Artificial Intelligence Tools
pred., classif., optim., LLM, ..

Event Driven

Facilities

Dashboard/View Builder & Mng.

Business Intelligence CSBL

Custom Themes

Synoptics & Widgtes

2D/3D Digital Twin

Tools

Routing, MulDyn.

Heatmap Gen.

Prediction Gen.

Measure and Compare

Notification Mng.

KPI Support

Scenario, What-If

SnapAdvisor / Generative AI

Applications

Traffic Optimization

Traffic Light Planning

Public Transport

Parking Management

Fines Management

Participation Mng.

Lighting Management

Building Management

Environment Mng.

Waste Management

Sharing/Pool Mng.

Energy Management

Tourism Management

Mobile Apps

Sharing / Market Place

A&A, RBAC, SSO, Blockchain, Resource Managers and Sharing

Third parties solutions

DEVELOPMENT ENVIRONMENT

Entity Directory

Entity Directory

Process Manager

Node-RED

Data Ingestion

Service Map

Dashboard Wizard

DevDash

Python

MLOps

Storage and Processing

Marketplace

Dashboards

Business Intelligence

CSBL Editor

Synoptics

Frontend

DETAILED ARCHITECTURE

Snap4City components are represented with green blocks

Platform Management:

Presentation | Dashboards | Business Intelligence | Visual Analytics | Smart Applications | Web & Mobile Apps

Dashboard Themes | Dashboard Wizard | Compare | Measure | Custom Theme

Dashboard Mng | Dashboard Builder | Widget Library | Scenario Editor | Synoptics | 3D Digital Twin | CSBL

Interoperability | Snap4City Node-RED Libraries | ASCAPI | API Mng | MQTT | FIWARE | kafka | WebSocket

Operations

BIMserver.center | openMAINT | Graphhopper | GeoServer

Operational Tools		Artificial Intelligence, DA Tools		MLOps, Dev. tools	Visual Analytic processes
Routing	BIM Server	Statistics	KPI Computing	python	R Studio	SSBL	JS	Node-RED
WorkflowMng	Notifications	Predictions	Optimization	CLEARML	Node-RED	What-if
Simulate	ckan	Node-RED	SUMO	Early Warning	……….	ML, AI,.. Libraries	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 | OpenSearch | virtuoso

SuperServiceMap | Data Management, HLT

Ni-Fi nifi

Linked Data triples

Aggregation Data Process | Processes and Rules | Blockchain | Brokers | FIWARE | Node-RED

IoT/Entity Directory | Harvester | Brokers | MQTT

Any protocol and format | Any protocol and format

Connectivity wired/wireless, IoT Edge, etc. | Node-RED

Any protocol and format | Any protocol and format

Device Layer

| GIS | BIM | OSM | Gateways | External Services | ERP | Social Media |

External Third Party Services

Authentication and Authorization: GDPR compliant KEYCLOAK OpenLDAP SNAP4CITY

Participatory and Living Lab Supports

Proc. Logic / IoT Applications Data Flow Logic Node-RED docker

docker SNAP4CITY

ONLINE TRAINING MATERIAL OVERVIEW

https://www.snap4city.org/944

The training course is open free of charge and includes frontal slides, full access to the platform and development tools, and exercises during the courses. Participants should be registered on https://www.snap4city.org performing the free registration as DISIT Organization or on their own Organization if they have one on Snap4City.

- **Overview:**
  - Objectives and Tasks, architecture and Digital Twin
  - Monitoring and Control: Mobility, Humans, Engagement, ..
  - Decision Support Systems, planning, what-if and optimization
  - Data Analytics, Artificial Intelligence, XAI, ML
  - Traffic Light Plan Optimisation
  - Traffic Infrastructure Optimization
  - Industry Domain: predictive maintenance
  - Autoclave Cycle: Energy Optimisation
  - Developing on Snap4City platforms
  - Training Suggestion and publications / further reading
  - Development Costs Advantages
  - Accelerating on Smart City Deploy with Snap4City
  - Platform Administration
  - Domains
    - Control and Planning
    - Mobility and Transport
    - Smart Energy and Smart Building
    - Environment and Waste Management
    - City Users' Services and Tourism Management
    - Assistants on Taking Decision, and for training development
    - Industry domain
- **Dashboard Purposes and Uses**
  - Main Data Kinds: data vs representations
  - Dashboards Main Concepts and simple Widgets
  - Creating a Snap4City Dashboard, wizard
  - Multi Data Map Widget
  - High Level Types, video, external services, synoptics
  - Selector for the Multi Data Map Widget
  - Data Inspector vs Data Processes Details
  - Dashboard Management

- **IOT App, Process Logic, Server Side Business Logic**
  - Recall on Snap4City Architecture
  - Node-RED
  - ProcessLogic as IOT App = Node-RED + Snap4City
  - Examples of IOT App for Smartening Solutions
  - Exploiting/Generating data by using: IoT App/ProcessLogic
  - External Service <-> IoT App/ProcessLogic
  - Dashboards <-> IoT App/Process Logic
  - Server Side Business Logic
- **Data Analytics and Artificial Intelligence**
  - Why and Where use DA, AI and XAI -> General Life Cycle, scenario editor, monitoring and control
  - Data Processing: KPI, traffic, emissions, public transport quality
  - From Data Analytics, DA to Artificial Intelligence, AI
  - List of the most relevant available DA and AI Solutions
  - Predictions and Anomaly detections: parking, biking, NOx, landslide, people
  - Computing: Higher Level Types Data and their representations: traffic, heatmaps, 3D
  - Human Behaviour, Engagement, Typical Time trends, WIFI sniffing
  - Using AI in main domains: Mobility and transport, traffic optimization, Smart Energy, Smart Building, routing
  - How AI/XAI, and Life Cycle, AI/ML requirements, XAI,
  - Using DA, AI/XAI in Snap4City infrastructures
  - Data Analytics <-> IoT App / Proc.Logic
  - MLOps, ClearML, exploiting clusters of GPU/CPU, using them from smart applications
  - Decision Support Systems and What-If Analysis, transport offer, DORAM tool
  - Integrated Traffic and mobility Simulation via SUMO
  - Routing, Multimodal Routing, Dynamic Routing
  - Predictive Maintenance
  - Industrial Applications
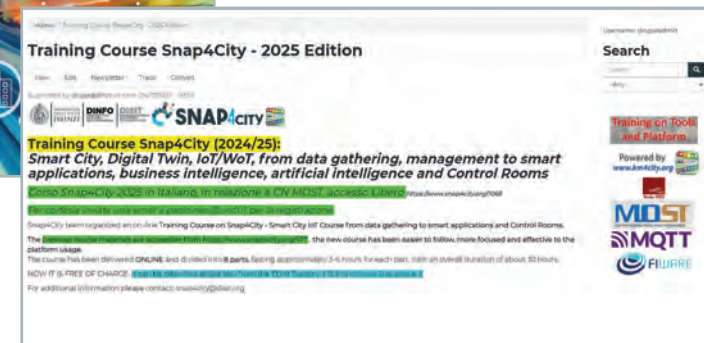
- **Data Ingestion and Interoperability**
  - When Solutions and tools for Data Ingestion and Interoperability are needed
  - Overview of Snap4City Data Storage and Stack
  - Knowledge Base: Modelling and Setting Up
  - High Level Types vs Ingestion Process
  - Data Ingestion Strategy and Orientation
  - Ingestion of Points of Interest with POI Loader
  - Models vs Devices/Entities and Registration
  - Verification of Data Ingestion
  - Digital Twin Data Inspector vs Data Processes Details
  - My Data Dashboard Dev to assess data on Open Search Storage
  - An Integrated Example for Time Series
  - Entities Ingestion with Data Table Loader
  - High Performance Ingestion via Python
  - FIWARE Smart Data Models on Snap4City
  - Ingestion of MyKPI with Proc.Logic / IoT App
- **Snap4City Platform Architecture, Interoperability, Management and Deploy**
  - Snap4City Architecture
  - Interoperability of Snap4City Platform
  - Exploiting Satellite data
  - Interoperability with respect to Hardware staff
  - Adding Features and Modules to Snap4City
  - FIWARE and Snap4City
  - Snap4City vs State of the Art Solutions
  - Smart City planning with Snap4City Team Support
  - The Role of the Living Lab Support
  - Snap4City Platform: Administration Overview
  - Snap4Tech: Smart Solutions as a Service
  - Deploy Snap4Tech solutions: Docker, Kubernetes, VM based
  - Monitoring with Snap4City Sentinel

- **Exploiting Snap4City API, and Web/Mobile Applications SDK**
  - Smart City API: Internal and External
  - Concepts and tools for using Knowlege Base, ServiceMap, API
  - Federated Knowledge Bases and Smart City APIs
  - Advanced Smart City API
  - Access to Protected data
  - Forging and managing: Mobile and Web Apps, MicroApplications
  - Exploiting AI/ML and microservices from Smart Applications
  - Web and Mobile App Development Kit (an example)
- **Developing Smart Applications & Business Intelligence Solutions**
  - Developing in the smart city IoT/WoT context
  - Smart Solutions Development Life Cycle
  - Analysis for Innovation (Co-Creation and Co-Working)
  - Design: Data, Data Models, Data Relationships
  - Design & Develop: Data Processes Proc.Logic / IoT App
  - Design & Develop of Data Analytics
  - Design & Develop: user interfaces, visual tools
  - Visual Analytic vs Data Analytics: Client Side Business Logic Intelligence
  - Design and Control of Smart Applications
  - What is missing here and you can get from former course

The course includes slides, full access to the platform and development tools.

SNAP4CITY

KM4CITY

CITY

INDUSTRY

ARTIFICIAL INTELLIGENCE