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www.snap4industry.org



INTRODUCTION

IoT Hubs, Applications and Solutions are presently addressing societal, environmental, Industrial and economic challenges. Smart solutions are progressively replacing traditional solutions being capable of exploiting a huge range of data channels, getting smarter, and cross exploiting data. An easy flexible, dynamic and highly interoperable platform is needed to increase sustainability, profit and full control of operational objectives, fully integrated with legacy solutions. IoT applications are abandoning the approaches based on single data sources and becoming aware of actual data channels where information and actions flow in multiple directions and Digital Twins and creating living labs with all stakeholders.

The use of the IoT/IoE (Internet of Things/Internet of Everything) is currently pervasive in all fields: smart city, industry 4.0, smart home, smart farm, smart city, smart waste, smart lighting, smart parking, etc. The approach has determined a change of paradigm, pushing towards the Digital Twins, but also in attributing to objects/things a large set of values and features in the digital world that would enhance their life and capabilities to be: manipulated, composed, viewed, transformed, copied, controlled, lend, etc., and to use them as instruments in other contexts. For example, the tags for tracking, the moving devices, the dashboards and Apps as receivers of action as actuators, etc.

Snap4Indutry/City provides real-time open-source solutions to support decision-makers to ground their daily operational actions on solid explainable artificial intelligent predictions, deductions and assessments. It provides a complete understanding of the context and its trends, receiving early warnings, anomaly detections, and performing simulation and what-if analysis. This information is used to suggest strategic interventions to improve services in multiple domains.

IoT has transformed how solutions are produced. To this end, powerful and Open platforms for creating smart **IoT Hubs, Applications** and **Services are needed and have to be capable to**:

- exploit and connect any kind of IoT Devices and Entities, with any protocol,
- exploit a large range of data types, value types, units, and concepts,
- exploit end-to-end secure solutions, devices, interfaces, storages and communications,
- use visual tools for fast prototyping and programming such as Node-RED,
- integrate data analytics, artificial intelligence, and ethics in multiple layers,
- use powerful tools for creating interactive real-time user interfaces: dashboards, synoptics, etc.
- be installed addressing IoT Edge, distributed environments, private and public cloud at reasonable and no licensing costs,
- respect privacy and provide GDPR compliance.

Snap4Indutry/City has been derived from Snap4City solutions. It is a 100% open-source platform used in many domains. It is an official FIWARE Platform and Solution (<u>https://www.snap4city.org/467</u>, https://www.fiware.org/) developed by many partners under the coordination of the DISIT Lab of the University of Florence, Italy. The platform is provided as "as a Service" basis on public or installed in your location (from yourself, as well as using several companies), no licence fee is needed. **Snap4Industry** has incorporated Km4City (<u>https://www.km4city.org</u>) ontological and semantic model to guarantee data interoperability among any kind of IoT Devices, device models, data entities, physical structures ranging from the city, industry, and home. And thus, also with **FIWARE Smart Data Models**.



Snap4Industry/City platform can manage your data, on-cloud, onpremises and hybrid solutions. As it currently performs in more than 40 areas in different countries such as: Italy, Spain, France, Bosnia-Herzegovina, Finland, Belgium, Greece, Croatia, Israel, Sweden, Australia, Brazil, Romania, Denmark, etc. On several installations on cloud and on-premise for industrial applications. An easy tool for Docker-based installations of the platform is also provided: https://www.snap4city.org/738

Snap4Industry/City covers multiple domains/scenarios (<u>https://www.snap4city.org/4</u>) in integrated Digital Twins and services:

• **Smart City:** mobility and transport, smart light, smart parking, smart governance, smart waste, smart health, traffic flow, people flow, etc.;

• **Smart Environment:** monitoring, pollutant predictions, landslides predictions, NOx prediction, NO2 very long-term predictions of annual average KPI, alerting, CO2 reduction, CO2 estimation from traffic, smart waste and management, decarbonization. For example, in Florence, Pisa, Livorno for NOX/NO2 predictions, and general pollutant monitoring in Tuscany, Antwerp, Helsinki;

• **Smart Industry (4.0):** depuration plants, production plants (monitoring industry plant, control and optimization, digital twin), predictive maintenance, integrated life cycles among different industry plants, such as on ALTAIR chemical plant; <u>https://www.snap4city.org/369</u>

• **Smart Home:** home automation, integrating with virtual assistants, commercial and custom devices and standards;

• Smart Farms: monitoring environmental data, water optimization.

Integration, ingestion and distribution. Snap4Indutry/City provides effective and simple tools and solutions for immediate data ingestion and data aggregation as well as an enormous range of protocols and standards. Snap4Indutry/City provides a range of tools for shortening the processes for manipulating simple and complex data such as: IoT Devices, satellite, OD Matrices, POI, KPI, Traffic Flows, Heatmaps, 3D Shapes/patterns, Trajectories, Flows, Video Streams, User profiles, Terrains, etc. https://www.snap4city.org/download/video/course2020/di/

Interoperability: In this enormous range of solutions, Snap4Industry is compliant with more than 140 protocols, file formats, and modalities of work https://www.snap4city.org/65:

• IOT: AMQP, COAP, MQTT, OneM2M, LoRa, LoRaWan, TheThingsNetwork, Libelium, KNX, Enocean, Zigbee, SigFOX, DALI, ISEMC, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, Daikin, IBIMET/IBE, AXIS, AIRqino, CISCO Meraki, ...

• Industry: ModBUS, OPC/OPC-UA, RS485, RS232, ...

• Web: HTTP, HTTPS, TLS, Rest Call, SMTP, TCP, UDP, NGSI V1-V2-LD, DATEX II, SOAP, WSDL, WebSocket, WS Secure, WFS, WMS, FTP, FTPS, WebRTC, RTSP, ONVIF, GML, ...

- Satellite: Copernicus, etc.
- Social and smart: Facebook, Telegram, Twitter, Alexa, Google Dot,...
- Events: SMS, EMAIL, Telegram, CAPS, ...

• Formats: XML, JSON, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, GeoJSON, Enfuser FMI, SVG, XLS, XLSX, TXT, HTML, CSS, IFC, binary, encoded, GTFS, Transmodel, ...

- Workflow: XPDL, BMP, ...
- **Database**: OLAP, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Phoenix, Elastic Search, Open Search, OBD2, AS400, MS Azure, ...

• **OS**: Android, Raspberry Pi, Linux, Windows, Local File System, ESP32, Arduino, ... **Snap4Indutry/City** provides open-source code for implementing Arduino, ESP32, Raspberry Pi, Linux, and Windows devices and solutions compliant with the platform and communicating securely via TLS, HTTPS, WSs.

Snap4Indutry/City exploits FIWARE Context Broker with its NGSI-V2/LD protocols, supporting: Smart Data Models, automated deployment, protected communications and multiple broker connections. The interoperability and modularity of Snap4 enables the creation of applications in a wide range of scenarios. Snap4Industry enables the creation of federations of solutions via SCAPI. SCAPIs are accessible and well documented for developers, allowing customization. Multi-tenant FIWARE Context Broker can feed data into the Snap4 platform. To further support developers, the Snap4 solution is supporting the concepts of living lab development and environment. https://www.snap4city.org/download/video/course2020/sys/

Security and Privacy: the Snap4Indutry/City solution passed the penetration and vulnerability tests and has been proven to be GDPR compliant. With Snap4City, it is possible to create end-2-end event-driven secure applications with connections from devices to dashboards and vice versa, including data processing, storage and data analytics. https://www.snap4city.org/549

Deploy and Platform Management: The solution is entirely distributed open source including the application layer, multitenancy aspects, assessment and auditing, resource management, etc. The Snap4Industry/City solution can be installed on private and public clouds (e.g., AWS, MS Azure) starting from an open-source virtual machine, as well as from docker compose - all modules being licence free. It provides a range of configurations from small standalone to exceptionally large-scale installations. Snap4Industry/City provides all needed management tools for user management, organization management, resource accounting, process management, high-level type management, reporting, multilingual support, multitenant support, scheduling, alerting, quality control, data inspection management, smart application management, dashboard control and usage, etc. https://www.snap4city.org/471

Training and Hackathons: Snap4Industry/City provides an open, free of charge and compressive training course and online development open platform for testing and using the solution. The Course is based on slides, videos and examples from its portal: <u>https://www.snap4city.org/577</u>. In most cases, Hackathons have been launched, for example with Sii-Mobility, Select4Cities, IEEE Intelligent Transportations Systems societies.







Snap4Industry/City provides a number of tools to manage the several different IoT Devices and data sources/streams connected and of the several data types in a unified manner, otherwise, the complexity of the solutions could be hardly managed:

• data channels of any kind connected via IoT Brokers, Gateways and directly to IoT App in Push and Pull (Discovery, Telemetry, Inquire, Commands and Notifications);

• multiple brokers, IoT devices, IoT Mobile Devices and IoT edge devices can be connected and managed via the **IoT Directory** which also performs automated discovery of devices on legacy brokers;

• internal and external IoT Brokers managed and harvested by the IoT Directory;

• remote IoT Edge Devices can be maintained, also updating the logic of control and data processing based on Node-RED;

• open and private data for each domain and organization;

• **IoT Edge**: supporting the installation of Snap4City processes and interfaced in embedded systems, such as Linux based, windows based, Arm, AXIS cameras, Raspberry Pi, Android, etc.

Snap4Industry/City **IoT Apps** are processed in Node-RED plus Snap4City library freely accessible on Node-RED library listed as: user, advanced and tunnelling. The processes can be executed periodically, or on-demand, eventdriven in real-time and/or quasi real-time as IoT Agents, Business Logics, data back-office automation, event-driven data management. It includes processes to produce data with respect to gateways, devices, brokers, services, IoT Edge devices, etc., by using some protocol and format (such as JSON, XML, encoded, binary).



The Snap4City Library for **Node-RED** is based on nodes called MicroServices, for this reason also the nodes are called MicroServices. Thus, IoT Apps are developed in **visual programming** data flow and/or datadriven flows in Node-RED exploiting Snap4City large library of more than 180 MicroServices covering areas of: data ingestion, data conversion, IoT Directory, storage, dashboards, protocols, data conversion, communications, workflow integration, event-driven, data analytics, social media, maps, geo reverse, tunnelling via IoT edge, etc., and are used to implement:

• **processes** for: data gathering, ingestion, harvest, crawl, aggregate, translate, transform, convert, collect, adapt, integrate, normalize, enrich, establish data entity relationships, complete, according to push and pull protocols;

• **migrations and transformations** of data among different installations and/or users of different Snap4City platforms and derived platforms;

• **business long of event-driven** user interface behind smart applications and dashboards via: **Regular widgets** as: single trend, time trends, multi series, Kiviat, bar series, buttons, knob, switches, donuts, etc.; **Custom Widgets** and **Synoptics**;

• controls of **Data Analytics** processes: parametrizing, scheduling, planning, etc.



Snap4Industry/City also supports the most recent solutions for **Global Digital Twin**: representing and navigating the city in 3D, with shapes of the building, heatmaps and animations, traffic flows, pins, devices, POI, KPI, etc. **Local Digital Twin**: representing 3D shapes of buildings, internal and external navigation, the association of 3D elements to devices, etc. <u>https://www.snap4city.org/716</u>

The Snap4Industry/City **Dashboard Builder** provides a wide range of graphic rendering tools to show and play with a variety of complex interactive data and graphic representations: maps, Orthomaps, tables, time trends, heatmaps, heatmap sequences/animations, traffic flows, origin-destination matrices and animations, traffic flow sequences/animations, typical trends, calendar heatmaps, Kiviat, bar series, custom widgets, animations, scenarios, routing, multimodal routing, public transport timeline, weather forecast, BIMs, buttons, 3D shapes on local (building) and global Digital Twins (for the whole city), synoptics of any kind, dynamic PIN on maps, trajectories, etc. https://www.snap4city.org/download/video/course2020/das/. Dashboard are easily created through the **Wizard** in a very easy manner to

Dashboard are easily created through the **Wizard** in a very easy manner to create solutions, along with complex applications with multiple dashboards and tools, up to complex control rooms, e.g., in Florence for Smart City, in ALTAIR for Industry Plant. They realize event-driven solutions working in real-time and provide interactive web tools and mobile Apps, for operators and final users.

analytic processes through machine learning, artificial intelligence, ethic explainable artificial intelligence (XAI) and statistical languages such as Python, Java, R-Studio, also exploiting Tensor Flow, Keras, and any kind of library for data analysis, machine learning and deep learning. Snap4Industry/City is distributing a number of Open Source data analytics tools and algorithms for: prediction, anomaly detection, heatmap production, clustering, classification, demand vs offer of transportation, and many others have been published on international top-level journals. Data Analytics are fully integrated into provided decision support tools and **What-IF analysis tools** in control rooms and for operators.

Data Analytics:

- Decision support systems, What-IF Analysis, ...
- Predictive Maintenance on Plant
- Anomaly Detection
- Smart parking, Smart Bike Sharing
- User Behaviour Analysis, via Wi-Fi, OD Matrices, trajectories
- Recognition of Used Transportation means

• Traffic Flow Predictions, in/out of the city, Traffic Flow Reconstruction, from Traffic Sensors Data

- Origin-Destination Matrices (from: Wi-Fi, Mobile Apps, etc.)
- Predicting Land Sliding

• Environmental Data Analysis and Predictions, early warning, Long Term Prediction of Annual Mean of NO2 index of EC

- User engagements, suggestions, nagging, recommendations
- Social media analysis via Twitter Vigilance.

See details on https://www.snap4city.org/download/video/course2020/da/





The usage of Snap4Industry/City has brought about improvements and has been of great benefit to a wide range of situations where it has been adopted. The very low costs for the adoption and implementation of changes, since they can be performed directly by city operators, have impressed many users. Snap4City can be freely installed on-premise with its full solution components. Its impact has been demonstrated in a wide range of solutions, pilots, and trials, including:

• Industry, home and area monitoring and security: a large set of sensors/actuators and devices working on event-driven, with a wide range of possible widgets for dashboards,

for reporting events and creating reactions towards actuators;

- **Strategic plan**: performing what-if analysis concerning critical conditions, planning production, system thinking on smart decision support systems;
- **Environment**: predicting NOX and long term NO2, monitoring pollutants of any kind and alerting, informing city users, waste management, landslide predictions;
- **Mobility and transport:** reducing people congestion, traffic congestion, monitoring and controlling traffic flow, simulating and analysing mobility and transport, reducing time for parking cars and bikes, reduction of pollutants, smart parking, etc.;
- **Energy:** rrecharging stations monitoring, smart light control;



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City management: predicting maintenance interventions, multichannel • alerting, anomaly detection as early warning, etc.. for resilience and control room;

People flow: monitoring, measuring, and alerting on critical cases. ٠

Snap4Industry/City is an official FIWARE Platform and Solution. Thanks to FIWARE's openness, interoperability and spread, it has enabled a faster integration and exploitation of the IoT aspects in the Smart City model of Km4City. The first usage of FIWARE technology by Snap4City was in the fields of Smart Industry and Smart Cities.

number of integrations and particular in the above mentioned cities and in several Industry plants and applications: chemical plants, production plants, planning events and production, energy vehicles production plants, robber production plants, etc. In several projects: REPLICATE H2020, RESOLUTE H2020, TRAFAIR CEF, Sii-Mobility MIUR, SODA4.0 of ALTAIR, 5G MIUR, MOBIMART Interreg, HERITDATA Interreg, Life Weee, AMPERE, Enterprise, Smart Ambulance, Italmatic, DIDA, and PC4City.

In 2019, DISIT Lab turned out to be the winner of the IoT/IoE challenge of Select4Cities PCP of EC and one year later won the ENEL-X Open Data Challenge in 2020. Currently, Snap4City is a platform of the EOSC (European Open Science Cloud), a library of Node-RED, and DISIT (University of Florence) is proud to be a Gold Member of FIWARE and an official FIWARE Platform and Solution, certified Consultant, certified trainer and provides two certified FIWARE Experts.





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• SCENARIOUS -

https://www.snap4city.org/4

• ORGANIZATIONS

https://www.snap4city.org/download/video/cov/

• INTEROPERABILITY

https://www.snap4city.org/283

• IOT APPLICATIONS

https://www.snap4city.org/22

- TUTORIAL https://www.snap4city.org/577
- INNOVATIONS
 <u>https://www.snap4city.org/343</u>
- MOBILE APPS
 <u>https://www.snap4city.org/489</u>
- DATA ANALYTICS
 <u>https://www.snap4city.org/524</u>

• INSTALLATIONS

https://www.snap4city.org/471

• ARTICLES -

https://www.snap4city.org/78

• 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

www.snap4industry.org









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