FIWARE
Open APIs for Open Minds

FIWARE IMPACT STORIES

SMART CITIES AND SMART INDUSTRY

Snap4City: FIWARE powered smart app builder for sentient cities

With the contribution of

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FIWARE - OPEN APIs FOR OPEN MINDS

April 29, 2021 @ FIWARE Foundation, e.V. – www.fiware.org

Challenge & Context

Cities are rapidly transforming their services in order to address current societal, environmental and economic challenges[1]. Vertical smart solutions are being progressively replaced by solutions capable of exploiting a huge range of data channels. Today, still, each city/area has its own criteria requiring a highly tailored solution, so only a flexible and dynamic platform can put a city in full control of its operational objectives. Cities are abandoning an approach based on data sources and becoming aware of actual data channels where information and actions flow in multiple directions. Multi-directional flows are key in implementing city operating systems involving daily tuning to deal with current challenges[2]. Cities are becoming smarter also due to regulatory pushes from international bodies and organizations such as the European Commission[3].

Snap4City is a 100% open-source platform developed under the coordination of Distributed Systems and Internet Technologies (DISIT Lab) of the **University of Florence**, Italy. The platform has at present a wide range of activities in the smart city and IoT/IoE (Internet of Things/Internet of Everything) integrated domains: **defining city strategies, control room, and computing key performance indicators which are used daily in both city and industry management**.

Since 2018, Snap4City has incorporated Km4City[4], providing a number of real-time open-source solutions **to support decision makers in cities and large industries to ground their daily operational actions on solid predictions, deductions and assessments**. It

[1] At the World Urban Forum, the World Bank will offer three big ideas that are essential for successfully implementing the New Urban Agenda: financing the New Urban Agenda, promoting territorial development, enhancing urban resilience to climate change and disaster risks. The Bank will also be showcasing some of the innovative knowledge and transformative actions that have proven to help end extreme poverty and boost shared prosperity in cities around the world. World Bank, 3 Big Ideas to Achieve Sustainable Cities and Communities, 31 January 2018. Link.

[2] According to European Commission: "Cities use technological solutions to improve the management and efficiency of the urban environment". This important aspect is reported in documentation provided by the EC in the EU Regional and urban development programme. Link.

[3] Other references to be cited: Sustainable Development Goals, European Green Deal, by ISO: ISO indexes, and WWF.

provides a complete understanding of the context and its trends, receiving early warning, anomaly detections, and performing simulation and what-if analysis. This information is used to suggest strategic interventions to improve city services and general quality of life, in multiple domains (e.g Smart Cities and Smart Industry).

Solution

In 2019, DISIT Lab turned out to be the **winner of the Select4Cities PCP of EC**[5] and one year later won the ENEL-X open data challenge in 2020[6]. Currently, Snap4City is one of the platforms of the EOSC (European Open Science Cloud)[7], and DISIT (University of Florence) is **proud to be a Gold Member of FIWARE and an official Powered by FIWARE Solution**.

Snap4City platform is managing data, with on-cloud and/or on-premise solutions, of currently more than **40 cities/areas in countries like Italy, Spain, France, Bosnia-Herzegovina, Finland, Belgium, Greece, Croatia, Israel, Sweden**.

Snap4City covers:

- **Mobility and transport** (smart parking, traffic flow reconstruction, traffic flow prediction, offer vs demand of transportation analysis, vehicle tracking, routing,

[4] Km4City is a knowledge base and a research line of DISIT lab mainly developed before the start of Sii-Mobility, RESOLUTE, REPLICATE projects, but improved with them as described in the following. Km4City started in the 2013 with a generic name, smart city ontology, it was named Km4City later. The major information and model at that time was focussed on the Open Data of Florence Municipality and exploiting Lamma for weather, and POI plus street maps from Tuscany Region. Main informative data set were: digital location, cultural activities, schools, commercial activities, etc.

[5] A European Commission project for selecting the best solution for IOT/IOE Smart City according to the view of Antwerp, Helsinki and Copenhagen by means of PreCommercial Procurement approach.

[6] Open Innovability is the crowdsourcing platform created by Enel for innovative and sustainable solutions and specifically for solutions that leverage open data generated by public administrations to produce improved city analytics enriching the digital services offered to citizens.

[7] The European Open Science Cloud (EOSC) is an environment for hosting and processing research data to support EU science.

multimodal routing, smart biking, reducing traffic congestion, etc.). For example in the REPLICATE H2020[8] project for **Florence, and in the cities of Pisa, Livorno, Modena, Santiago de Compostela**, on TRAFAIR CEF[9]; **Pisa and Siena** for smart biking with Sii-Mobility national smart city actions;

- **Energy** (smart light, control room on energy production and recovering, charging stations); For example in REPLICATE for recharging stations, for CAPELON[10] partner in Sweden for Smart Light;
- **Environment** (monitoring, pollutant predictions, decarbonization, NOx prediction, NO2 KPI predictions, alerting, CO2 reduction, smart waste, ...). For example, **in Florence, Pisa, Livorno** for NOX/NO2 predictions, and general pollutant monitoring;
- **Industry 4.0**, depuration plant, production plants (monitoring industry plant, control and optimization, digital twin), such as on ALTAIR chemical plant;
- **Governance control and KPI** (people flow, tourism, POI, utilities, quality of life assessment and control, building automation, digital twin, sustainability, smart decision support). For example: in REPLICATE H2020 for Smart City Control Room of **Florence**, in **Antwerp** for monitoring people flows with PAXCounters, and in **Dubrovnik**, **Valencia** for monitoring people flow and tourism aspects with HeritData.

In this large range of solutions, **Snap4City is compliant with more than 100 protocols** and it is interoperable with GIS (Geographical Information Systems), CKAN[11] and IoT Networks protocols (IOT protocols)[12].

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[8] REPLICATE – REnaissance of PLaces with Innovative Citizenship And Technologies – is a European research and development project that aims to deploy energy efficiency, mobility and ICT solutions in city districts.

[9] Providing a dataset to describe air quality maps and forecast maps in six European cities of different sizes: Zaragoza, Florence, Modena, Livorno, Santiago de Compostela, Pisa. Developing an urban air quality prediction service based on weather forecasts and traffic flows, active in the six cities for two years. These are the objectives of the two-year European project (2018-2020) Trafair "Understanding Traffic Flows To Improve Air Quality" co-funded by the European Connecting Europe Facility (CEF) programme in the telecommunications sector.

[10] CAPELON is Capelon has worked with device communications and advanced meter readings for over 20 years and with smart streetlights for over a decade. The base for the connectivity in Capelon's products has been a reliable and open standard powerline communication. CAPELON is a FIWARE Gold Member since 2019.

Figure 1 - Snap4City System Overview

The goal is to support cities and businesses to improve performance and reduce costs by connecting all management and control domains. To this end, **Snap4City platform can rely on FIWARE Compliance and exploits FIWARE Context Broker**[13] with its **NGSI-V1 and V2 protocols**[14], supporting protected communications and

[11] CKAN is a powerful data management system that makes data accessible – by providing tools to streamline publishing, sharing, finding and using data.
[12] OMA NGSI, LoraWAN, SigFOX, OneM2M, MQTT, LwM2M, AMQP, COAP) (smart home protocols and solution such as: Philips, Alexa, Sonoff, TPlink, etc.), Industry 4.0 protocols (OPC-UA, MODBUS, etc.), databases (MySQL, AS400, Azure, ORACLE, etc.), services (WS, Rest, etc.), microservices, media, social media, WebSocket, mobile App (to provide info, questionnaires, suggestions and to collect feedback, images, etc.), etc.
[13] Context Broker is the core and mandatory component of any "Powered by FIWARE" platform or solution. It enables to manage context information in a highly decentralized and large-scale manner.
[14] NGSI V1 and V2NGSIv2 allows users to create/update attributes (and metadata) whose values use JSON native types (number, boolean, string, etc.). By default, NGSIv1 uses a JSON parser that converts numbers and boolean values to string at creation/update time. Thus, an attempt of setting A=2 using NGSIv1 will actually store A="2" in the Orion database. However, some degree of native types is possible in NGSIv1 storing, using the autocast feature. Link

multiple broker connections. **The interoperability of FIWARE plus the flexibility and modularity of Snap4City together enable the creation of applications in a wide range of scenarios such as those mentioned above**. Snap4City enables the creation of federations of Smart Cities via its Smart City API and NGSI-based solutions. All Snap4City APIs are accessible and well documented for developers, allowing customization. Thanks to **FIWARE's approach, the operating multi-tenant FIWARE Context Broker can feed data into Snap4City platform**. To further support developers, Snap4City is supporting the concepts of living lab development and environment.

The Snap4City solution **passed** the **PENtest and vulnerability test** 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, including data processing, storage and data analytics**. Details of the architecture have been published in peer reviewed top journals having IEEE Access[15]. The solution is distributed **entirely open source** including the application layer, multitenancy aspects, assessment and auditing, resource management, etc.

The Snap4City solution can be installed on private and public clouds starting from an open source virtual machine, as well as from docker compose - all elements being licence free. It provides a number of configurations from small standalone to very large installations.

[15] IEEE Access is an award-winning, multidisciplinary, all-electronic archival journal, continuously presenting the results of original research or development across all of IEEE's fields of interest. Supported by article processing charges (APC), its hallmarks are a rapid peer review and publication process of 4 to 6 weeks with open access to all readers. IEEE Access publishes articles that are of high interest to readers: original, technically correct, and clearly presented. The scope of this journal comprises all of IEEE's fields of interest, emphasizing applications-oriented and interdisciplinary articles. Link

How it works

As described above, the **Snap4City solution is capable of working with multiple data channels of any kind, as well as multiple FIWARE solutions**. Once data channels are established, city entities are modeled in a Knowledge Base (grounded on Km4City ontology and LD linked data) and become ready for semantic queries exploiting relationships as: spatial, temporal and relational. Multiple brokers, devices and edge devices can be connected and managed via the IoT Directory. Remote IoT Edge Devices can be maintained, also updating the logic of control and data processing based on Node-RED. Snap4City can manage open and private data for each domain and organization.

The Snap4City Dashboard Builder provides a huge amount of graphic rendering tools to show and play with a variety of complex data (e.g. maps, Orthomaps, tables, trends, heatmaps, traffic flows, typical trends, calendar, Kiviat, barseries, custom widgets, animations, scenarios, routing, buttons, 3D, synoptics, etc.). They are composed by means of the Wizard[16] in a very simple and easy manner to create vertical solutions, along with complex applications with multiple dashboards and tools, up to complex control rooms as it has been installed e.g. in Florence for Smart City and 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. The Snap4City Dashboard Builder provides a large number of interactive features, joining 3D representation, Digital Twin representation and navigation, integration with workflow management systems for ticketing and management, synoptics for industrial monitoring and animations, etc., supporting protection and GDPR.

Snap4City is fully integrated with data processing tools such as **Node-RED** of **JS Foundation** in which the open **Snap4City Library** is providing a large set of

[16] A software wizard is a user interface type that presents a user with a sequence of dialog boxes that lead the user through a series of well-defined steps. Tasks that are complex, infrequently performed or unfamiliar may be easier to perform using a wizard.

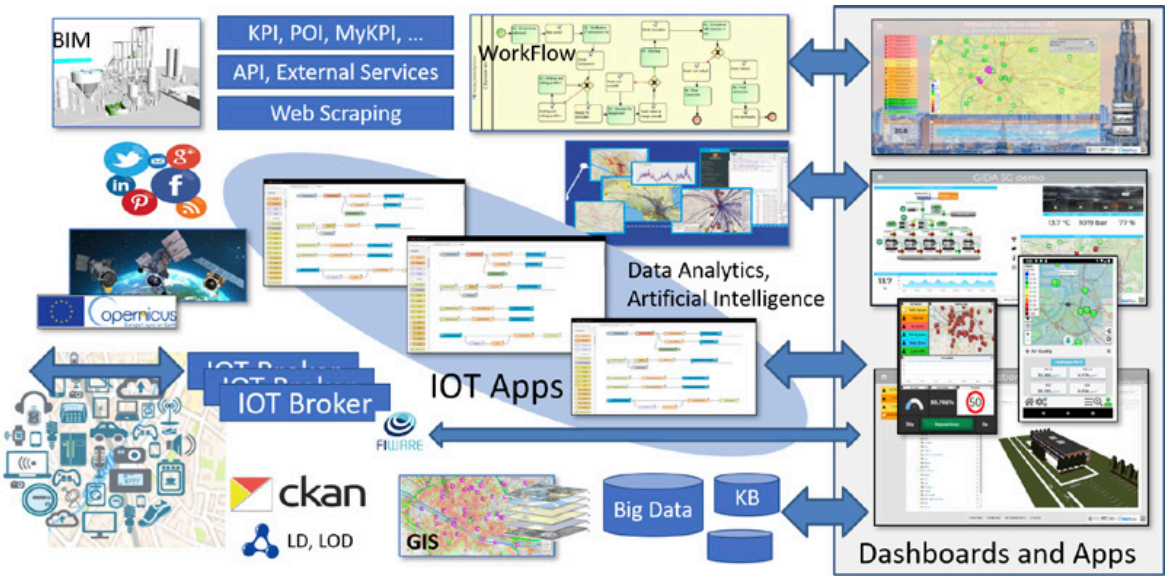

Figure 2 - Snap4City Dashboards and Apps

MicroServices for creating data adapters, integration, business logic and data transformations. They can be easily used to compute any kind of indicators and follow the KPIs needed by cities such as the EC indicator on pollutants (ISO37120, 37122); city indexes and so on.

In addition, Snap4City fully supports the development of real time data analytic processes through machine learning, artificial intelligence and statistical languages such as Python, Java, R-Studio, also exploiting Tensor Flow, Keras, and any kind of library for data analysis, learning and deep learning. Snap4City is also developing and distributing a number of **Open Source data analytics tools and algorithms for prediction, anomaly detection, heatmap production**, and many others have been published on international top level journals for Smart Parking, Smart Biking, traffic flow reconstruction, traffic flow prediction, NOX prediction, NO2 prediction, people flow analysis, public transportation analysis, routing, etc. Data Analytics can be fully integrated into What-IF analysis tools in control rooms and for operators.

Benefits & Impact

The usage of Snap4City has brought about improvements and has been of great benefit to a wide range of situations where it has been implemented. The very low costs for the implementation of changes, to be done directly by city operators, has impressed many users[17]. Snap4City can be freely installed on premise with its full solution components. Its impact has been demonstrated in a wide range of solutions, pilots, projects and trials, including:

- **Mobility and transport**: reducing people congestion, traffic congestion, monitoring and controlling traffic flow, simulating and analysing mobility and transport, smart parking;
- **Environment**: predicting NOX and long term NO2, monitoring pollutants of any kind and alerting, informing city users;
- **Energy**: recharging stations monitoring, smart light control;
- **Strategic planning**: performing what-if analysis with respect to critical conditions, planning production, system thinking on smart decision support systems;
- **City management**: predicting maintenance interventions, multichannel alerting, anomaly detection as early warning, etc.;
- **People flow**: monitoring and alerting on critical cases.

The possibility of establishing bi-directional connections with data channels in the above-mentioned domain, enabled higher levels of integration and exploitation, thus allowing the generation of unexpected hints and deduction, thanks to the support of the tools for data analysis and what-if analysis.

[17] Q. Han, P. Nesi, G. Pantaleo, I. Paoli, "Smart City Dashboards: Design, Development and Evaluation", Proc. of the IEEE ICHMS 2020, International Conference on Human Machine Systems, September 2020. Link

Added Value through FIWARE

FIWARE was adopted by Snap4City in 2016 as reported in the roadmap, making it an official Powered by FIWARE 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**. Its capability and compliance at European level allowed them to perform a huge number of integrations. NGSI has been adopted by Snap4City as the core part of the ingestion process using FIWARE's IOT Orion Broker. Recently, Snap4City utilized **FIWARE's Context Broker for extending the Snap4City federation of Smart Cities, and have started working on the NGSI-LD integration which is adding to the Km4City**, an additional semantic level with additional capabilities. In the above listed projects and solutions, **FIWARE has been used by DISIT Lab as a core part of the Snap4City solution, and in particular in the cities of Florence, Antwerp, Pisa, Livorno, Modena, Santiago de Compostela, Valencia, Dubrovnik, Lonato del Garda** (for Smart Parking), and in the projects mentioned before: REPLICATE H2020, RESOLUTE H2020, TRAFAIR CEF, Sii-Mobility, SODA of ALTAIR, 5G MIUR, MOBIMART, HERITDATA, and PC4City[18].

References

- Snap4City
- Training
- Scenarios, projects, contracts
- Technical Document
- Installations
- News

[18] For further information read here

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Categories

Domains (s)	Smart Cities, Smart Mobility, Smart Industry, Smart Lighting, Smart Parking, Smart Biking
User (s)	Cities, Regions
Key words	IoT, IoE, Context Broker, Data Source, GDPR, APIs, NGSI-LD

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