Smart City and BIM

https://www.Snap4City.org

Paolo Nesi, paolo.nesi@unifi.it
https://www.Km4City.org
https://www.disit.org
Information in Smart City is not so simple

- Data Coverage:
  - POI, IOT, shapes,
  - maps, orthomaps, GTFS, GIS WFS/WMS,
  - calibrated heatmaps,
  - traffic flow, typical trends,
  - trajectories, events,
  - 3D, BIM, Workflow,
  - Dynamic icons/pins,
  - OD Matrices, scenarios,
  - prediction models, ....
  - decision support, ....
  - Synoptics, animations,
  - social media, Routing, etc.

Need a huge amount of standards
←back and forward→
Fast Tailored Deploy of Smart Applications & Decision Supports

exploiting our tools to cope with

- any data, format
- any channel, protocol
- any AI/ML
- any place
- online development
- multi-tenant
- secure
- GDPR, privacy

→ low costs
→ easy to evolve
Requirements and Objectives

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

• **Open Source** based 100%
  – any **Standard**

• **Multi tenant:** to cope with multiple organization with a single installation

• **Scalable, Robust, Distributed** and Decoupled, modular, Service Oriented, open to external services and data sets, big data

• **Heterogeneous:** any device, private and public, custom and..

• **Security by Design:** HTTPS, TLS, ... compliant with EC

• **User Centric Design:** privacy by Design (and **GDPR**), personalized, personal data management, ...
DASHBOARDS AND APPS - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS

- EXPERT SYSTEM KNOWLEDGE BASE STORAGE
- BIG DATA ANALYTICS ARTIFICIAL INTELLIGENCE BUSINESS INTELLIGENCE MACHINE LEARNING
- DATA FLOWS, WORKFLOWS MICROSERVICES MANAGEMENT
- METHODOLOGIES COURSES AND COMMUNITY LIVING LABS DEVELOPMENT TOOLS

Snap4City (C), May 2021
Ingestion, aggregation → exploitation

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

• **Expert System** semantic queries accessible via:
  • **Smart City API** for Apps and third party
  • **MicroServices** data driven develop via visual language Node-RED
Solutions: reliable, secure and fast to realize

• Via Snap4City tools
  • Dashboard Wizard
  • Dashboard Builder
  • Data/Visual Analytic

• Smart Solutions results to be
  • Real time data drive
  • Secure end-to-end
  • GDPR compliant
  • Reliable, interoperable
  • Auditable, marketable
2021: Snap4City/Industry Numbers

- **Domains**: mobility, energy, people flow, environment, Industry 4.0, vehicle tracking, Tourism,
  - smart park, smart waste, smart bed, smart ambulance, smart light, etc...
  - Predictions, simulations, anomaly detection, ..
- 5 running installations, 13 projects, 12 pilots, 9 Countries
- > 100 Protocols

**Scalable from vertical to large deploy**

**On the largest deploy** [https://www.Snap4City.org](https://www.Snap4City.org)
- 17 Organizations / tenant
- > 80 applications on: cities, areas, scenarios
- > 4800 users
- > 1200 Dashboards
- > 15 mobile Apps
- > 2 Million of structured data per day in the larger deploy
- > 500 IoT Applications/node-RED /Docker
- > 680 web pages with training
- > 40 videos, training videos

**Main Organizations/areas**
- Antwerp area (Be)
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- DISIT demo (multiple)
- Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Helsinki area (Fin)
- Livorno area (I)
- Lonato del Garda (I)
- Modena (I)
- Mostar, Bosnia-Herzegovina
- Pisa area (I)
- Pont du Gard, Occitane (Fr)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Venezia area (I)
- WestGreece area (Gr)
BIM Integration Dashboard

Sinottico Sintesi Impianto Altair 2

Smart City Functional Architecture

- **Data Sources, External Services**
  - Pull Data

- **Data Ingestion, aggregation, regularisation, reconcile**
  - IOT Directory, NIFI, special tools

- **Knowledge base**
  - Semantic Reasoners

- **Indexing and aggregating**
  - Elastic Search

- **Data Analytics, Simulations, Special Tools**
  - R Studio, Tensor Flow, Python, ...

- **IOT Applications, Business Logic**
  - Node-RED + Snap4City MicroServices

- **Federaion**
  - Search and Query, Smart City API, Web Socket Server, GIS, Facet, semantic

- **Rendering**
  - Acting, Widgets, Synoptics, MicroApps

- **Authentication, Authorization, Platform & Processes Management, Data Inspector, Digital Twin, ...**

- **Inform, announce, Act!, warning, alarms, What-IF, ...**

**Back-End**

**Front-End**

- **Environment, Water, energy**
- **Shops, services, operators**
- **Social Media**
  - Crawler and Manager
- **Public Services, Govern, events ...**
- **Sensors, IOT Cameras, Wi-Fi**
- **Transport systems, Mobility, parking**
• **Open Data:**
  - Data gate, federation of Open Data Portals
  - IOT App, ETL proc(PULL)

• **IOT Networks:**
  - IOT Application processes, data driven or PULL
  - IOT Brokers (Push) → IOT Shadow

• **Web Pages:**
  - Web scraping, crawling processes

• **Satellite data**

• **Social media:** Twitter, Facebook,..
  - Twitter Vigilance, IOT App

• **Mobile Apps**
  - Smart City API

• **Files upload:** CSV, Excel, etc.
  - IOT Applications, ETL

• **REST API, WS, FTP, LD, LOD, etc.**
  - IOT Applications, ETL

• **Data base accesses**
  - GIS: WFS, WMS
  - ETL, IOT Application

---

### Any kind of data and flows

- **SNAP4City**
- **IOT Device**
- **IOT Broker**
- **IOT Edge**
- **Web Scraping**
- **DataGate**
- **API, External Services**
- **GIS data, Maps, ...**
- **Rest Call ... MS**
- **External Data Stores**
  - **LD, LOD**

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**Snap4City (C), May 2021**
Standards and Interoperability


https://www.snap4city.org/65
Service Map (Toscana)

Regular Services
- Accommodation
- Advertising
- AgricultureAndLivestock
- CivilAndREngineering
- CulturalActivity
- EducationAndResearch
- Emergency
- Environment
- FinancialServices
- GovernmentOffice
- HealthCare
- IndustryAndManufacturing
- ITDevice
- MiningAndQuarrying
- ShoppingAndService
- TourismService
- TransferServiceAndRenting
- UtilitiesAndSupply
- Wholesales
- WineAndFood

Search text into service
Service providing value type:
select: value type
n. results: 0
search range: 2 km
search area: select

Some complete Use Cases
Smart City Control Room
Florence Metropolitan City

- Multiple Domain Data
  - Context: Thousands OD, POI, IOT, etc.
  - mobility and transport: accidents, public transport, parking, traffic flow, Traffic Reconstruction, KPI, ...
  - AND: civil protection, gov KPI, covid-19, social & social media, people flow, tourism, energy, ...

- Multiple dash/tool Levels & Decision Makers
  - Real Time monitoring, Alerting, quality assess.
  - Predictions, KPI, DSS, what-if analysis

- Historical and Real Time data
  - Billions of Data

- Services Exploited on:
  - Multiple Levels, Mobile Apps, API

- Since 2017
Major of Florence City

Florence Case

- **Mobility:**
  - quality of public transportation service (mean delay on bus-stops)
  - public transport operators schedule and paths, routing, multimodal routing
  - traffic flow reconstruction
  - Smart parking: predictions
  - Accidents and events, Log, heatmaps

- **Environment:**
  - smart irrigators
  - smart waste
  - Sensors: PM10, PM2.5,....
  - Heatmaps: PM10, PM2.5,....
  - NOX predictions

- **Energy:**
  - recharging stations (fast and reg.)
  - consumption meters (smart info)
  - smart light, street lights

- **Weather:**
  - Forecast and actual

- **Social:**
  - smart benches
  - Twitter monitoring, Sentiment analysis, NLP text
  - TV camera streams

- **People Flows:**
  - Wi-Fi, people flow
  - Origin destination matrices

- **Governmental and Communications:**
  - KPI of the City
  - Digital Signage
  - Civil protection, Resilience (Resolute)

- **Tourism and Culture:**
  - POI, etc.

- **Analysis:**
  - what-if routing, scenarios,
  - traffic flow, environmental predictions
Estimation of the mean waiting time at bus stops
3D Map beta Testing

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjM2MA==#
Twitter Vigilance

Early Warning

Predictive models

Hot flows

Attendance at long lasting events: EXPO2015

Attendance at recurrent events: TV, football
Tuscany Region
Firenze, Pisa, Livorno, Prato, etc.
Mobility and Transport
Traffic Flow Analysis

• Multiple Domain Data
  • Traffic Flow sensors, city structure, weather

• Decision Makers Multiple Locations
  • Real time Monitoring, predictions
  • Traffic Flow Predictions,
  • Traffic Reconstructions, routing
  • Dashboards, What-IF analysis
  • Mobile App, people flows

• Historical and Real Time data

• Services Exploited on:
  • Dashboards, Mobile App

• Since 2017, 2019
Traffic Flow Reconstruction for the cities

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc5NQ==
Traffic Flow Monitoring - Firenze - Cloned2

COVID-19 1st phase

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjY1MQ==
Accidents and elements blocking Points and Shapes taken into account for:

– Routing
– Traffic Flow reconstruction
– Evacuation paths
– Rescue team paths

Assessment on the basis of changes:

– Mobility demand assessment
– Mobility Offer assessment

Mobility and Environment What-IF Analysis

This dashboard contains data derived from actual sensors and predictive values under validation.

The App is a Bidirectional Device

- GPS Positions
- Selections on menus
- Views of POI
- Access to Dashboards
- searched information
- Routing
- Ranks, votes
- Comments
- Images
- Subscriptions to notifications
- ...

**Derived information**
- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed
- ..... 

**Produced information**
- Accepted ?
- Performed ?
- ...

**Users**

**System**
Users’ Engagement

Inform
- Air Quality forecast is not very nice
- You have parked out of your residential parking zone
- The Road cleaning is this night
- The waste in S. Andreas Road is full

Engage
- Provide a comment, a score, etc.

Stimulate / recommend
- Events in the city, services you may be interested, etc.

Provide Bonus, rewards if needed
- You get a bonus since you parked here
- We suggest: leave the car out of the city, this bonus can be used to buy a bus ticket
Campaing on Sustainable Mobility

Sii smart.
Sii-Mobility!
Scarica, viaggia, Vinci!

Dal 15 aprile al 15 luglio scegliere il trasporto pubblico ti premia! Scarica l’app “Toscana dove, cosa”, guadagna punti viaggiando in autobus e Vinci tanti fantastici premi!
Per maggiori informazioni visita il sito info.sii-mobility.org

In palio per te
Carnet multicrosa Cpt e voucher per:

Farmacie Comunali
Pisa

Zona Multisale Odeon
Teatro di Pisa

Dal 15 aprile al 15 luglio scegliere il trasporto pubblico ti premia! Scarica l’app “Toscana dove, cosa”, guadagna punti viaggiando in autobus e Vinci tanti fantastici premi.
Per maggiori informazioni visita il sito info.sii-mobility.org
User Behavior Analyser for Collective Profiling

Who

When

What

Where they go ahead

Why?
Scalable OD Matrix
Impact of COVID-19

• Multiple Domains Data
  • Traffic, environment, People, parking, stock options, Twitter, tc.

• Decision Makers Multiple Locations
  • NO2 long term predictions
  • Twitter analysis

• Historical and Real Time data

• Services Exploited on:
  • Dashboards
  • Social media,
  • Sentiment Analysis

• Since 2019, 2020
People Monitoring on Pub Services

DIGIPOLIS Antwerp

• Multiple Domain Data
  • PAX Counters: museum, pub services, COVID-19

• Multiple Levels & Decision Makers
  • Business Intelligence Dashboards
  • People flow, OD flows
  • Detection of critical conditions

• Historical and Real Time data
  • 20 fixed PaxCounters
  • 2 Mobile PaxCounters

• Services Exploited on:
  • Dashboards, Mobile Apps, API/data
  • Fully Controlled Devices by Digipolis

• Since 2019
Antwerp (B)

Antwerp City Overview - A5

Please note that the data results are not always based on real data.

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTQwNw==
Programmable PAX counting

Mobile PAXCounter 01 in Antwerp

Antwerp
Mobile Apps
Dashboard monitoring the Mobile App:
- Collecting the clicks
- Describing the community of users in terms of the profile aspects
- Measuring the time spend, and topics of interest of the users, etc.
Snap4Altair Decision Support supervision and control, Industry 4.0

• 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
Altair Control room
Some Altair Flows
Workflow for Ticket management

OpenMaint: BPM Workflow management, team assignment, material control, ...

IOT App, Data event firing, event detection and firing

Critical event management

Consumptions/productions

Events/actions

Business Intelligence Maintenance

Dashboards and actions

Sinottico Sintesi Impianto Altair 2
1,865 Numero di eventi nel periodo
264.491 50th percentile of ore tra inizio e fine lavoro
673.151 Media ore passate tra inizio e fine lavoro

CLORURO FERRICO STANDARD
CARBONATO DI POTASSIO
CICLO SALAMOIA
IPOSODIO
IMPIANTO 3FC
CARICO PRODOTTI

Maintenance Intelligence
BIM view of the Altair Chemical Plant

Tuscany Region
Firenze, Pisa, Livorno, Prato, etc.
Environment and Quality of Life
Air Quality Predictions

• Multiple Domain Data
  • Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3, ....
  • 3D City structure, weather, ...

• Multiple Decision Makers
  • Pollutant Predictions: NOX, NO2, ...
  • City officers, energy industries
  • Dashboards, What-IF analysis
  • Traffic Flow Reconstruction

• Historical and Real Time data
  • Billions of Data

• Services Exploited on:
  • Dashboards, Mobile App

• Since 2020

Cities of:
Firenze, Pisa, Livorno

Air Quality Directive

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging period</th>
<th>Objective and legal nature and concentration</th>
<th>Comments</th>
<th>Concentration</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>One day</td>
<td>The target value is 25 μg/m³.</td>
<td></td>
<td>25 μg/m³ (1)</td>
<td></td>
</tr>
<tr>
<td>PM2.5</td>
<td>Calendar year</td>
<td>Target value, 10 μg/m³.</td>
<td></td>
<td>10 μg/m³ (10% percentile over three years)</td>
<td></td>
</tr>
<tr>
<td>PM10</td>
<td>Calendar year</td>
<td>Limit value, 20 μg/m³.</td>
<td></td>
<td>20 μg/m³ (1)</td>
<td></td>
</tr>
<tr>
<td>PM10</td>
<td>Maximum daily 8-hour mean</td>
<td>Target value, 40 μg/m³.</td>
<td></td>
<td>40 μg/m³ (1)</td>
<td></td>
</tr>
<tr>
<td>NO2</td>
<td>One hour</td>
<td>Not to be exceeded more than 15 times a calendar year</td>
<td></td>
<td>200 μg/m³ (1)</td>
<td></td>
</tr>
<tr>
<td>NO2</td>
<td>Calendar year</td>
<td>Limit value, 40 μg/m³.</td>
<td></td>
<td>40 μg/m³ (1)</td>
<td></td>
</tr>
</tbody>
</table>
Tuscany Region

• Dashboards & Services:
  – **Mobility**: public transport operators schedule and paths, traffic Fi-Pi-Li main road, parking status and predictions, traffic sensors, Origin Destination matrix, routing, multimodal routing, etc.
  – **Social**: Hospitals and triage, etc.
  – **Environment**: sensors, heatmaps, alerting,
    • **Pollution** Forecast
    • **Weather** Forecast,
  – **Culture and Tourisms**
  – Etc.

• **Mobile App and MicroApplications**:
  – Tuscany in a Snap (all stores)
  – Tuscany where what... km4city (all stores)
• **Numbers**: 1.5 M complex events per day
Traffic vs NOX

Traffic Flow Manager test

Sun 25 Apr 15:47:50

Heatmap Controls:
- 24h
- Max Capacity:
  - 2021-04-23 15:00:00

Traffic Heatmap Controls:
- 24h
- Max Opacity:
  - 2021-03-23 10:21:00

NOX
µg/m³
- 0-15
- 16-35
- 36-60
- 61-75
- 76-90
- 91-105
- 106-125
- 126-150
- > 151

Traffic Heatmap Interface:
- Free street
- Fast traffic
- Heavy traffic
- Traffic map
- Sensors status

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test

Traffic vs NOX

Traffic Flow Manager test
Lonato del Garda
Smart City / Smart Parking + Environment
Reverberi, Lonato del Garda

- Multiple Domain Data
  - Smart Parking, Environment, Wi-Fi
- Multiple Decision Makers
  - City Officer, operators
  - Data monitoring, alerting
  - analytics
- Historical and Real Time data
  - Dashboards
- Services Exploited on:
  - Dashboards, API
- Since 2019
Smart Lonato del Garda

Smart Parking Monitoring

Lonato del Garda - cam

Snap4City (C), May 2021
Smart Light Control of CAPELON

- Energy Domain
  - Smart Light
  - IoT Orion Broker FIWARE
- Dashboards
  - Map coverage on Sweden
  - Monitoring and real-time control
  - Energy control, analytics
  - Direct control
- Historical and Real Time data
- Services Exploited on:
  - Multiple Levels, API
  - Dashboards
- Since 2020
Real time Light Control Example
Dubrovnik, Croatia
**Dubrovnik**

- Tourism Domain
  - Counting People
  - TV Cameras and WiFi
  - Social Media
- Dashboards
  - Monitoring and real-time control
  - People flow
  - Twitter Vigilance
- Historical and Real Time data
- Services Exploited on:
  - Dashboard
- Since 2020

Snap4City (C), May 2021
Valencia, Spain
Valencia, FSMLR

- Tourism Domain
  - Counting People
  - Environmental data
  - Social Media
- Dashboards
  - Monitoring and real-time control
  - People flow
  - Twitter Vigilance
- Historical and Real Time data
- Services Exploited on:
  - Dashboard
- Since 2020

HeritData - Valencia FSMLR
Mostar, Bosnia-Herzegovina
Mostar

- Tourism Domain
  - KPIs
  - People flows
  - POI
- Dashboards
  - Monitoring KPI
  - POI, flows
- Historical and updated data
- Services Exploited on:
  - Dashboard
- Since 2020
Pont du Gard, Fr
Pont du Gard

• Tourism Domain
  • KPIs
  • Social Media

• Dashboards
  • Monitoring KPI
  • Twitter Vigilance

• Historical and updated data

• Services Exploited on:
  • Dashboard
  • Since 2020

Snap4City (C), May 2021
West Greece
West Greece

• Tourism Domain
  • KPIs
  • Social Media
  • People Flows
  • Social Media

• Dashboards
  • Monitoring KPI
  • People flows
  • Twitter Vigilance

• Historical and updated data

• Services Exploited on:
  • Dashboard

• Since 2020
Santiago di Compostela
Traffic Flow Reconstruction for the cities

Santiago di Compostela

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

• **Dashboards & Services:**
  - **Environment & Weather**, PM10, PM2.5, NO, SO2, CO, noise, etc.
    - Sensors values, Heatmap & **Alerts** on critical
    - FMI Enfuser prediction: PM10, PM2.5, ...
    - GRAL predictions PM10, validations
    - Private sensors in Jätkäsaari area (personal dashboards)
  - **Mobility**: Traffic Sensors, Operators, routing, multimodal routing, whatif
  - **Social**: Twitter Vigilance, early warning
  - **Life in Helsinki**: OD matrix people flow, Twitter Vigilance SA, hot places, etc.
  - **Tourism and Culture**

• **Mobile App and MicroApplications:**
  - Helsinki in a Snap (all stores)

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

Snap4City (C), May 2021
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc1Mg==
Environmental Data Predictions: GRAL

- GRAL predictions: PM10, NOX, ....
  - Comparison wrt real time values in actual value of Sensors
  - Graz Lagrangian Model.
- GRAL model takes into account:
  - pollution sources (for example the vehicles, their distribution on the streets, the about of pollution they produce according to their distribution over time and space, etc.),
  - structure of the city (streets and shape 3D of the buildings),
  - weather forecast (wind intensity and direction), etc.
- GRAL can be applied on NOX, PM10, PM2.5, ... or any other particles
Environmental Devices hosted by Citizens

My Sensor 373773207E330118 - Helsinki - H3

Values from Your Sensor

<table>
<thead>
<tr>
<th>Sensor Mark</th>
<th>Real Time PM10</th>
<th>Real Time PM2.5</th>
<th>Real Time AQI</th>
<th>Average Last Hour PM10</th>
<th>Average Last Hour PM2.5</th>
<th>Sensor reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki-0</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Helsinki-1</td>
<td>1.5 μg/m³</td>
<td>6.5</td>
<td>29.6</td>
<td>1.5</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Helsinki-2</td>
<td>4.5 μg/m³</td>
<td>10</td>
<td>58</td>
<td>4.5</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Helsinki-3</td>
<td>1 μg/m³</td>
<td>1.5</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Helsinki-4</td>
<td>0.9 μg/m³</td>
<td>0.5</td>
<td>8</td>
<td>0.9</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Helsinki

Snap4City (C), May 2021
Prato
Smart City vs Industry 4.0
GIDA set up

Smart City data from many sources

ModBus to Snap4City Gateway Edge

5G network devices

IOT Data Shadow Snap4City

IOT Applications

Telemonitoring Telecontrol

Dashboards and Apps

Big Data Analytics, Artificial Intelligence
GIDA 5G demo

13.6 °C

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjIyNg==
Roma Demo3 (Qualità dell'Aria)

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjcyNg==
Scenario: SnapBot: Real Time Smart City services via Telegram
Scenario: Copernicus Satellite Data
Scenario: SmartBed, Materasso Intelligente
MicroServices Suite for Smart City Applications
Scenario: MODBUS for Snap4Industry Snap4City Applications
Scenario: MOBIMART Interreg: MOBilità Intelligente MARE Terra
Scenario: City of Roma case, mobility and environmental data
Scenario: Herit-Data video and aims
Scenario: Control Room vs Video Wall
Scenario: Snap4Home the case of: Alexa, Philips, Sonoff, TP-link, etc. (Italiano)
Scenario: how to manage maintenance and accidents workflows
Scenario: Snap4Home, how to exploit Snap4City solution on home automation
Scenario: Energy Monitoring
Scenario: Multipurpose User Engagement Tools
Scenario: 5G Enabled Water Cleaning Control (smart city, industry 4.0)
Scenario: High Level Control of Industrial Plant (industry 4.0)
Scenario: Vehicle Monitoring via OBD2
Scenario: Events and Museums Monitoring in Antwerp
Scenario: High Resolution Prediction of Environmental Data
Scenario: Mobility and Transport Analyses in multiple cities
Scenario: People Flow Analysis via Wi-Fi
Scenario: Antwerp Pilot on Environmental Data
Scenario: Helsinki Pilot on Environmental Data
Scenario: Firenze Smart City Control Room
Scenario: Mobile & Web App: Toscana Where What ... Km4City, Toscana in a Snap
Scenario: Helsinki Pilot on User Behaviour
Scenario: Antwerp Pilot on User Behaviour

Data Analytic: Origin Destination Matrices, Algorithms and tools
Data Analytic: Traffic Flow Reconstruction
Data Analytic: in general, and the cases of Antwerp and Helsinki
Data Analytic: Predicting Air Quality
Data Analytic: Analyzing Public Transportation Offer wrt Mobility Demand

Snap4City Overview, 2021
Data Type Management

GDPR Compliant
GDPR: General Data Protection Regulation

Users may decide to:

– provide access to who, for do what, until when consented
– accept terms of use by signed consent for data management service

From each service, the user is capable to:

– See what we collect in terms of Data Type: traces, logs, paths, profiles, accesses, IOT devices, sensors, maps, etc.
– Download, delete, inspect Data
– Auditing and Revoke access or grant access right to each single Data
– Delete all Data in single shot or singularly (forget all about me)

• Correctness
• Transparency
• Security
• Integrity
• Privacy
• Auditing
• ...

Snap4City (C), May 2021
GDPR: General Data Protection Regulation

If personal data are published by the owner:

– the data are released anonymously,
  → also in this case they can be revoked at any time:

Snap4City is also compliant to GDPR Technical Constraints as it:

– Performs Secure connections in any private data exchange
– Encrypts data store for all private data
– Decouples data and personal IDs
– Audits private data usage
Manage Profile and MyPersonalData

For each Data Type:

- Start as private \(\rightarrow\) making them public (anonymous) and revoke
- The Owner is the only one that can: (1) modify values; (2) change the ownership
- Define/revoke Delegation to Access
- Delete/forget per Data Type and “me all”!
- Auditing
## GDPR vs Snap4City

### GDPR Compliance Verification Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Verif.</th>
<th>Reqs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signed consent</td>
<td>UI</td>
<td>R8</td>
</tr>
<tr>
<td>User profile management and control</td>
<td>UI</td>
<td>R13</td>
</tr>
<tr>
<td>Data Type private as default</td>
<td>UI</td>
<td>R8</td>
</tr>
<tr>
<td>Rights to access per element</td>
<td>UI</td>
<td>R9</td>
</tr>
<tr>
<td>Rights to transfer per element</td>
<td>UI</td>
<td>R10</td>
</tr>
<tr>
<td>Rights to erase per element and total</td>
<td>UI</td>
<td>R13</td>
</tr>
<tr>
<td>Rights to revoke/change per Data Type</td>
<td>UI</td>
<td>R10</td>
</tr>
<tr>
<td>An interface for Right management for Data Type</td>
<td>UI</td>
<td>R9</td>
</tr>
<tr>
<td>Clear Terms of Use and Privacy Policy</td>
<td>UI</td>
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<tr>
<td>Auditing Tools for Data Type</td>
<td>UI</td>
<td>R14</td>
</tr>
<tr>
<td>Publish as Anonymous</td>
<td>UI</td>
<td>R9</td>
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<tr>
<td>Encrypt personal users’ data</td>
<td>Code</td>
<td>R12</td>
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<tr>
<td>Secure Authentication and Authorization</td>
<td>Code</td>
<td>R3</td>
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<tr>
<td>Data protection by Design</td>
<td>Code</td>
<td>R17</td>
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<tr>
<td>Secure connection</td>
<td>Code</td>
<td>R6</td>
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<tr>
<td>Security Control, data breach control, anonymization, etc.</td>
<td>PEN Test</td>
<td>R15, R16, R18</td>
</tr>
</tbody>
</table>

Details on the paper cited in the following slide
Smart City IoT Platform Respecting GDPR Privacy and Security Aspects

CLAUDIO BADIO, PIERFRANCESCO BELLINI, ANGELO DIFINO, AND PAOLO NESI (Member, IEEE)
Department of Information Engineering, University of Florence, 50134 Florence, Italy
Corresponding author: Paolo Nesi (paolesnesi@unifi.it)
This work was supported in part by the European Union’s Horizon 2020 Research and Innovation Program under Agreement 948996.

ABSTRACT The Internet of Things (IoT) paradigm enables computation and communication among tools that everyone uses daily. The vastness and heterogeneity of devices and their composition offer innovative services and scenarios that require a new challenging vision in interoperability, security and data management. Many IoT frameworks and platforms claimed to have solved these issues, aggregating different sources of information, combining their data flows in new innovative services, providing security robustness with respect to vulnerability and respecting the GDPR (General Data Protection Regulation) of the European Commission. Due to the potentially very sensitive nature of some of these data, privacy and security aspects have to be taken into account by design and by default. In addition, an end-to-end secure solution has to guarantee a secure environment at the final users for their personal data, in transit and storage, which have to remain under their full control. In this paper, the Snap4City architecture and its security solutions that also respect the GDPR are presented. The Snap4City solution addresses the full stack security, ranging from IoT Devices, IoT Edge on-premises, IoT Applications on the cloud and on-premises, Data Analytics, and Dashboarding, presenting a number of integrated security solutions that go beyond the state of the art, as shown in the platforms comparison. The stress test also included the adoption of penetration tests verifying the robustness of the solution with respect to a large number of potential vulnerability aspects. The stress security assessments have been performed in a piloting period with more than 1200 registered users, thousands of processes per day, and more than 1.8 trillion of complex data ingested per day, in large cities such as Antwerp, Helsinki and the entire Tuscany region. Snap4City is a solution produced in response to a research challenge launched by the Select4Cities H2020 research and development project of the European Commission. Select4Cities identified a large number of requirements for modern Smart Cities that support IoT (IoT) (Internet of Things) Everything in the hands of public administrations and Living Labs, and selected a number of solutions. Consequently, at the end of the process after 3 years of work, Snap4City has been identified as the winning solution.

INDEX TERMS End-to-end, GDPR, IoT, security, smart city.

I. INTRODUCTION

IoT (Internet of Things) is becoming a disruptive technology, especially for city users of metropolitan areas. The pervasiveness of IoT Devices, integrated in common objects, is becoming increasingly deeper. The addresses space for these devices would be enough to point any instances of any devices at any moment without restrictions. Diffuse products that implement Low-Power Wide Area Networks (LPWAN) technologies for IoT introduced by SigFox and Semtech (LoRa, Long Range) have been gaining interest and have been under intense deployment campaigns worldwide [1]. At the same time, short-range IoT devices (based on technologies such as IEEE 802.15.4 or Bluetooth Low Energy, BLE) [2] are sold in increasing quantities and are already able to support scenarios for smart homes, energy metering and Industrial automation. On the other hand, the start of the diffusion of 5G devices and services is creating huge expectations in leveraging IoT technologies, as the killer application of previous technologies in metropolitan areas.
Development of Solutions
Develop Mobile & Web Applications
Exploiting Snap4City Smart City Services

Analysis & Design
- Analysis
- Design
- Data Discovery
- Data Ingestion

Data Analytics
- Data Analytics Development
- Special Tool Development
- Dashboard Development

IOT App Development

Deployment
- Deploy
- Testing
- Publication Production

Advanced Smart City API and MicroServices

Snap4City Mobile & Web Apps Development Kit

Application Requirements Analysis

Application Development

Publication Production

Testing

Smart City Services

Mobile and Web Apps

Snap4City (C), May 2021
**On Line Training Material (free of charge)**

<table>
<thead>
<tr>
<th>what</th>
<th>1st part (*)</th>
<th>2nd part (*)</th>
<th>3rd part (*)</th>
<th>4th part (*)</th>
<th>5th part (*)</th>
<th>6th part (*)</th>
<th>7th part (*)</th>
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<tbody>
<tr>
<td>PDF</td>
<td>General</td>
<td>Dashboards</td>
<td>IOT App, IOT Network</td>
<td>Data Analytics</td>
<td>Data Ingestion processes</td>
<td>System and Deploy Install</td>
<td>Smart City API: Web &amp; Mob. App</td>
</tr>
<tr>
<td>Interactive</td>
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<td>2:48</td>
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</table>

Snap4City (C), May 2021
Overview

• April 2021

• [https://www.snap4city.org/drupal/sites/default/files/files/Snap4City-PlatformOverview-April-2021-V5-3.pdf](https://www.snap4city.org/drupal/sites/default/files/files/Snap4City-PlatformOverview-April-2021-V5-3.pdf)
Dashboard and tools Development
The Wizard helps you in selecting only possible combinations of data vs graphic representation.
Select the area of your interest: panning and zooming

Select the

- graphic aspect of your interest, or
- High Level Type of your interest, or
- Make a search if you a have a precise idea or
- Act on filters: nature, subnature, type, name, value, date, health, owner, ...
- Combine them as you like

- Select the lines of your interest
- Then click on Next and get the Dashboard by wizard
Dashboard List and Editor
Special Custom Widgets

- Smart parking
- Smart Energy
- Smart Light
- Smart ...
- Energy View
- Custom Controls
Other examples

• Virtual Actuators (sensor-actuator)
  – From: Dashboard
  – To: IOT App, MyKPI, other Synoptics

• Virtual Sensors
  – From: MyKPI, Sensors, IOT App, other Synoptics
  – To: Dashboards

Snap4City (C), May 2021
Sinottico Sintesi Impianto Altair 2

Home
DCS Real Time V3 Planning
DCS Real Time Cloramento
DCS Real Time Settimanale
DCS Marcia Marce
DCS Marcia Settimanale
DCS Stocaggi Marca
DCS Stocaggi Marce Settimanale
Sinottico di azione impianto
Sinottico di azione impianto

Idrogeno gas

Elettrolisi

Cloro gas

KCl

E.E.

NaCl

RTO online

DCS Real Time - Settimanale

Sistema di gestione della produzione

RTO online

DCS Real Time - Settimanale

Sistema di gestione della produzione

RTO online
Alert Registration

Alerting Generation

This dashboard contains data derived from actual sensors and predictive values under validation.

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA0OQ==
Typical Time Trends

Typical Time Trend Example

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MzA5MQ==

Snap4City (C), May 2021
How the Dashboards exchange data

Snap4City BigData Storage and KB

IOT Broker Orion Quantum Leap

API, External Services, MicroApp

ServiceMap Super ServiceMap

Dashboards

- Req. ServiceURI
- Req. KPI, Metric ID
- Req. MyKPI ID
- Traffic Flow, MAPS, Heatmaps
- GIS, HTTPS URLs
- ServiceURI (ID)
- MyKPI, Metric (ID)
- Dynamic Data, computed into IOT Application
- Rx. Dynamic Data
- Event Driven Synoptics
- Actions, Show

IOT Application

Snap4City (C), May 2021
Dashboard-IOT App

MyKPI variable onchange

Synoptics

MapClick

From Dashboard to IOT App

impulse button
numeric keyboard
switch button
dimmer
geolocator
dropdown
form
coordinates from map
event driven my kpi
synoptic read
synoptic subscribe
Dashboard-IOT App

From IOT App to Dashboard

IOT Application

Snap4City (C), May 2021
IOT Devices

- LoraWAN + Arduino + I2C, NGSI
- Arduino, Wi-Fi, NGSI
- Snap4All IOT Button
- ESP, NGSI, Wi-Fi, BT

IOT Edge Devices

- Snap4All PAX Counter
- LoraWAN
- WIFI, NGSI, GPS
- IOT Edge NodeRED:
  - Raspberry Pi, NGSI, WiFi, RJ45,
  - Android, LINUX, Windows, ...
- IOT Edge NodeRED:
  - NGSI, WIFI, RJ45, GPS
- LoraWan Gateway:
  - IOT Edge, NGSI, WIFI, RJ45, GPS

Any Sensor / Actuator Open to other protocols
IoT Application Development
smartening the solutions
Data Adapation
Transformation, Conversion
Integration
Business Logic vs Dashboards
Data Analytics control
Everywhere: Cloud, on IoT Edge Devices
April 2021 collection
Two Snap4City Libraries

https://flows.nodered.org/search?term=snap4city
Two Snap4City Libraries

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

AND: From Resource Manager
Two Snap4City Libraries

- Search and management of Services, POI, Parking, Public Transport, etc.
- Event management, ticket management
- Routing, Data Analytic, Open Data processing
- IoT device registration, Virtual Devices full control
- IOT adaptation, network management
- Dashboard management
- Personal data management, KPI, etc.

---

Nov. 2020 collection

Snap4City (C), May 2021
Registering Alerting events

Control Room Operator
- Monitor traffic flow, Environment, Car parking, Cycling, First aid, temp., ...
- Registering Events: classification
- Changing status
- Acting

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MzA0OQ==

Snap4City (C), May 2021
SnapBot

• provides real time smart city services to Telegram users, geolocalized, when you like, what you like
• active on Tuscany in all provinces and cities according to the data accessible on [https://www.snap4city.org](https://www.snap4city.org)
• Services on
  – Public Transport (more than 10 different operators),
  – bike sharing, parking lots,
  – traffic flow, weather warnings,
  – Air quality, pollutant,
  – find your location, etc.
IOT App of SnapBot: OneShot Services

Exploiting Node-RED Snap4City MicroServices
Development of Data Analytics
Data Analytics in R Studio

Con Tensor Flow
Data Analytics Dev. in R Studio and/or Tensor Flow

- Swagger
- SPARQL, FLINT
- LOG.disit.org
- Ontology Schema
- Knowledge Base, Km4City
- Big Data Store Facility
- Smart City API from Knowledge Base and other tools
- Creating Micro Services
- Using them into IOT Applications
- Saving Sharing Reusing
- Resource Manager

Snap4City (C), May 2021
Data Analytics Development in Python, Swagger, SPARQL, FLINT, Ontology Schema, LOG.disit.org, Knowledge Base, Km4City, Big Data Store Facility, Smart City API from Knowledge Base and other tools, Creating Micro Services, Using them into IOT Applications, Coding, Testing, Saving, Sharing, Reusing, Resource Manager, 133, Snap4City (C), May 2021.
R Studio and Python algorithms are automatically transformed into MicroServices for your IOT Applications.
Predicting City Users on Areas
Traffic Flow Reconstruction/prediction
Predicting Pollution
Predicting at EXPO2015
Early Warning Water Bomb
Early Warning Hot in Tuscany
Scalable multiresolution OD matrix
What-IF Analysis
Free Parking Predictions
Active on Mobile Apps as:
- "Firenze dove cosa" 
- "Toscana dove cosa"
Predicting City Areas Crowdn level charaterizing Users' Behaviors
Peopl Flow prediction
Data Analytics
<table>
<thead>
<tr>
<th>Main Data Sources</th>
<th>Antwerp</th>
<th>Helsinki</th>
<th>Where</th>
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</thead>
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<tr>
<td><strong>Antwerp</strong></td>
<td><strong>Helsinki</strong></td>
<td><strong>Where</strong></td>
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<tr>
<td><strong>Discovery near to me</strong></td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>Discovery along a path</strong></td>
<td>X</td>
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<tr>
<td><strong>Discovery in an area, shape</strong></td>
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<tr>
<td><strong>Full Text search</strong></td>
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<tr>
<td><strong>Routing: pedestrian</strong></td>
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<tr>
<td><strong>Routing: pedestrian quite</strong></td>
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<td><strong>Routing: private vehicles</strong></td>
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<td><strong>Transportation: Multimodal Public Transport</strong></td>
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<tr>
<td><strong>heatmaps: weather (Temp, Humidity)</strong></td>
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<tr>
<td><strong>heatmaps: environmental variables, PM10, PM2.5, NO2, EAQI</strong></td>
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<tr>
<td><strong>heatmaps: environmental variables, Noise</strong></td>
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<tr>
<td><strong>heatmaps: safe on bike (Antwerp)</strong></td>
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<tr>
<td><strong>heatmaps: Enfuser prediction, PM10, PM2.5, AQI</strong></td>
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<td><strong>heatmaps: piking values any place</strong></td>
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<td>X</td>
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<td><strong>heatmaps: GRAL prediction, PM10</strong></td>
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<td><strong>Comparison: Enfuser, GRAL, Real Time</strong></td>
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<td><strong>Sensors Data Time Trends, &amp; drill down</strong></td>
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<td><strong>Weather Forecast</strong></td>
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<td><strong>Origin Destination Matrices</strong></td>
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<tr>
<td><strong>Typical trajectories</strong></td>
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<td><strong>Services Suggestions on mobiles</strong></td>
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<tr>
<td><strong>Alerts on critical cases: several variables</strong></td>
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<tr>
<td><strong>The most used services</strong></td>
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<td><strong>Twitter Trends Daily</strong></td>
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<td><strong>The auditing of user and living lab</strong></td>
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<td><strong>Self assessment</strong></td>
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<tr>
<td><strong>Trajectories from mobile RAX Counters</strong></td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
• Resilience
  • Resilience and risk analysis
  • Early warning computation
  • What-if analysis, dynamic routing, origin destination matrices production from a large range of sources

• Mobility and transport
  • Traffic flow reconstruction from sensors and other sources
  • Predictions for: traffic flow, smart parking, smart bike sharing, etc.
  • Analysis of the demand vs offer of mobility according to public transportation and multiple data sources
  • Accidents heatmaps
  • Tracking fleets, people, via devices: OBU, OBD2, mobile apps, etc.
  • Routing and multimodal routing

• Environment and weather
  • NOX, PM10 pollution prediction on the basis of traffic flow, 48 hours
  • Long term prediction of European Commission KPIs on NOX, PM10, etc.
  • Heatmaps production, dense data interpolation

• User and Social
  • People flows prediction and reconstruction, via Wi-Fi, mobile apps, etc.
  • User engagement for sustainable mobility
  • User’s behaviour analysis, origin destination matrices, hot places, time schedule, Recency and frequency, permanence, etc.
  • People flow analysis from PAX Counters
  • Social media analysis on specific channel, specific keywords: see Twitter Vigilance, for NLP and Sentiment Analysis, SA
  • Tweet proneness, retweet-ability of tweets, impact guessing
  • Audience prediction to TV channels and physical events

• Generic
  • Data quality assessment, prediction, anomaly detection
  • Maintenance prediction and costs predictions
  • Estimation of KPI and local indexes for: quality of life, 15 minutes, etc.
Predicting Models for Administrators & City Users

- **Aiming at improving**
  - quality of service, distributing workload
  - early warning

- **Predictions:** Short (15 min, 30 Min) and mid Term (1 week)

- **Data Analytics:** ML, NLP/SA, Clust., ...
  - Traffic Flows → multi-flow reconstruction
  - Parking Status → free slots
  - Environmental Alarms
  - Air Quality parameters and indexes
  - People Flows (Wi-Fi, Twitter) → crowd, #number of people
Origin Destination Matrix Estimation

Wi-Fi based

Recency and frequency
User Behaviour Analysis

Distinct APs: 343
Distinct APs (last 24 hours): 311
Distinct Users (last 180 days): 1102098
Distinct Excursionists (last 180 days, < 24 h): 687025

Recency

First Day actions

New City Users VS Returning
Characterizing City Areas

Predicting City Areas Crowd level characterizing Users’ Behaviors

Wi-Fi based
Prediction and Identification of Anomalies

- Cluster confidence
- AP average and confidence
- Actual AP trend for today
- AP prediction for the next time slot in the day on the basis of past weeks

Predictive precision of the 95%

Guessing number of users of Wi-Fi Access Points
## Free Parking Predictions

### Careggi car park

<table>
<thead>
<tr>
<th>Model features</th>
<th>BRNN model results</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-squared</td>
<td>RMSE</td>
<td>MASE</td>
</tr>
<tr>
<td>Baseline</td>
<td>0.974</td>
<td>24</td>
<td>1.87</td>
</tr>
<tr>
<td>Baseline + Weather</td>
<td>0.975</td>
<td>24</td>
<td>1.75</td>
</tr>
<tr>
<td>Baseline + Traffic sensors</td>
<td>0.975</td>
<td>24</td>
<td>2.04</td>
</tr>
<tr>
<td>Baseline + Weather + Traffic sensors</td>
<td>0.975</td>
<td>24</td>
<td>1.87</td>
</tr>
</tbody>
</table>

### Active on Mobile Apps as:

- «Firenze dove cosa»
- «Toscana dove cosa»

Precision: 97.5%
Traffic Flow Reconstruction for the cities

https://www.snap4city.org/dashboardSmartCity/view/index.php?idDashboard=MTC5NQ==
Computation of Traffic Flow Evolution
### Traffic Flow predictions

<table>
<thead>
<tr>
<th>XGBoost Model Results</th>
<th>$R^2$</th>
<th>RMSE</th>
<th>MASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensors of Group 1</td>
<td>0.95</td>
<td>215</td>
<td>0.89</td>
</tr>
<tr>
<td>Sensors of Group 2</td>
<td>0.91</td>
<td>178</td>
<td>0.82</td>
</tr>
<tr>
<td>Sensors of Group 3</td>
<td>0.86</td>
<td>127</td>
<td>0.92</td>
</tr>
</tbody>
</table>

![Vehicle Flow vs. Time](chart.png)
Heatmap Firenze - trafair

different data

Florence, Pisa, Livorno

https://main.snap4city.org/view/index.php?iddasboard=MTUzMg==
Anomaly Detection

Accidents vs Traffic

Accidents Density
Yearly NO2 Florence Monitoring Dashboard

Predicting the 2021


Snap4City (C), May 2021
Welcome to DORAM powered by SNAP4CITY

The public transportation system has been analyzed in the City, considering the service offer vs. mobility demand. The top-thirty most crowded stops are presented on the right panel and on the map. Please, select your desired scenarios or a stop on the map to perform other analyses.

Scenario Selector

Choose a scenario: Actual scenario

Actual scenario: Describes the current status of the public transportation network. (More Info)

https://www.snap4city.org/odanalyzer/#b
# Mobile App Development

## Smart City API and Federation

### On Line Training Material (free of charge)

<table>
<thead>
<tr>
<th>Part</th>
<th>1st part</th>
<th>2nd part</th>
<th>3rd part</th>
<th>4th part</th>
<th>5th part</th>
<th>6th part</th>
<th>7th part</th>
</tr>
</thead>
<tbody>
<tr>
<td>what</td>
<td>General</td>
<td>Dashboards</td>
<td>IOT Apps</td>
<td>IOT Network</td>
<td>Data Analytics</td>
<td>Data Ingestion</td>
<td>System and Deploy</td>
</tr>
<tr>
<td>PDF</td>
<td><img src="image" alt="PDF" /></td>
<td><img src="image" alt="PDF" /></td>
<td><img src="image" alt="PDF" /></td>
<td><img src="image" alt="PDF" /></td>
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<td><img src="image" alt="Interactive" /></td>
<td><img src="image" alt="Interactive" /></td>
<td><img src="image" alt="Interactive" /></td>
</tr>
<tr>
<td>Video1</td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
<td><img src="image" alt="Video1" /></td>
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<tr>
<td>Video2</td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
<td><img src="image" alt="Video2" /></td>
</tr>
<tr>
<td>Video3</td>
<td><img src="image" alt="Video3" /></td>
<td><img src="image" alt="Video3" /></td>
<td><img src="image" alt="Video3" /></td>
<td><img src="image" alt="Video3" /></td>
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<tr>
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<td><img src="image" alt="Video4" /></td>
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<td><img src="image" alt="Video4" /></td>
<td><img src="image" alt="Video4" /></td>
<td><img src="image" alt="Video4" /></td>
<td><img src="image" alt="Video4" /></td>
</tr>
<tr>
<td>Duration</td>
<td>255</td>
<td>316</td>
<td>843</td>
<td>200</td>
<td>248</td>
<td>235</td>
<td>547</td>
</tr>
</tbody>
</table>

Snap4City (C), May 2021
A Mobile App may refer to one Smart City API Server (for Area 1) via SUPER and receive data from the Federated SUPERS (Area 2) if navigation, queries, etc. are leading to discover out of the addressed KB.

- SUPER can be used for creating redundant and/or balanced distributed solutions for Federated KB. See Area 2, the two KB in the front.
- Federated SUPER can have overlapped KB even totally.
- A Mobile App can be developed to support multiple Smart City API servers, for balancing and

The usage of Super is not mandatory so that separate services can be produced as well
- Super and Nodes present the same Smart City APIs.
External Smart City API

https://www.km4city.org/swagger/external/index.html
External Smart City API

- **Advanced Smart City API**
  - To access the Service Map resources and query

- **Km4city Web App API**
  - To exploit MicroApplications created as tools for Dashboards, totem, web Apps, etc.

- **Orion Broker K1-K2 Authentication**
  - To communicate with IOT Orion Brokers exploiting the Secure Filter of Snap4City.

- **Heatmap**
  - To save and access to HeatMaps of the Heatmap server
The App is a Bidirectional Device

- GPS Positions
- Selections on menus
- Views of POI
- Access to Dashboards
- searched information
- Routing
- Ranks, votes
- Comments
- Images
- Subscriptions to notifications
- …

**Produced information**
- Accepted ?
- Performed ?
- …

**Derived information**
- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed
- …

**Produced information**
- Suggestions
- Engagements
- Notifications
- …
Integration with Telegram: SnapBot solution
• provides real time smart city services to **Telegram** users, geolocalized, when you like, what you like

• active on Tuscany in all provinces and cities according to the data accessible on **Https://www.snap4city.org**

• Services on
  – Public Transport (more than 10 different operators),
  – bike sharing, parking lots,
  – traffic flow, weather warnings,
  – Air quality, pollutant,
  – find your location, etc.
Data Model, Ingestion and Management
• Open Data:
  – Data gate, federation of Open Data Portals
  – IOT App, ETL proc(PULL)

• IOT Networks:
  – IOT Application processes, data driven or PULL
  – IOT Brokers (Push) → IOT Shadow

• Web Pages:
  – Web scraping, crawling processes

• Satellite data

• Social media: Twitter, Facebook..
  – Twitter Vigilance, IOT App

• Mobile Apps
  – Smart City API

• Files upload: CSV, Excel, etc.
  – IOT Applications, ETL

• REST API, WS, FTP, LD, LOD, etc.
  – IOT Applications, ETL

• Data base accesses
  – GIS: WFS, WMS
  – ETL, IOT Application

Any kind of data and flows
Data Modeling
Road Graph (Tuscany region)
132,923 Roads, 389,711 Road Elements
318,160 Road Nodes, 1,508,207 Street Numbers
Info on: points, paths, areas, etc.
Services (20 cat, 512 cat.)
16 Public Transport Operators
21,280 Bus stops & 1081 bus lines

Dynamic/real-time as in Tuscany Region
• Real time bus lines: 144 updates X day X line
• 1081 Transport Pub Lines: 1-2 up per day, time-path
• >210 parking lots status: 76 updates X day X sensor
• >796 traffic Sensors: 288 updates X day X sensor
• 285 weather area: 2 updates X day X area
• >12 hospital Triage status: 96 updates X day X FA
• 600 Environmental data: 20 updates X day X sensor
• 39 Bike Sharing racks data: Pisa and Siena
• 12 Pollination data, 37 air quality data
• 177 recharging stations
• Smart benches, waste mng, irrigators, lighting, ...
• Florence ent.events: about 60 new events X day
• Different kinds of Florence traffic events,
  [1600 Fuel stations: 1 update X day X station]
  [Wi-Fi: > 400.000 measures X day]
• App mobiles: >50.000 measures X day
• more than 40.000 distinct users X day
• From 600.000 to 4.5 M Tweets X day
• + many IOT sensors personal and industrial ...
A POI is defined as an element of a set (collection) and with general info:

- **Nature**: ........
- **Subnature**: ....

Specific info for each POI

- **Location**: lat, lon
- **A set of Attributes**
  - www, email, opening time, phone, cap, address, city, etc.
- Eventually a link to data
### How to Ingest

All of them can be shown on Dashboards, what about manipulate them!!!!

<table>
<thead>
<tr>
<th>HLT, High Level Types++</th>
<th>GPS</th>
<th>Static</th>
<th>Dynamic</th>
<th>Single</th>
<th>Time Series</th>
<th>Trajectory</th>
<th>HTTP</th>
<th>How to ingest/change/manage/see</th>
</tr>
</thead>
<tbody>
<tr>
<td>POI (Point of Interest)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>DataGate, ETL, IOT App, API</td>
</tr>
<tr>
<td>MyPOI data</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, UserInterface, API</td>
</tr>
<tr>
<td>Sensor data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Dashboard, IOT Directory, IOT App, UserInterface, API</td>
</tr>
<tr>
<td>Sensor Actuator data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Dashboard, IOT App, UserInterface, API</td>
</tr>
<tr>
<td>MyKPI data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Dashboard, IOT App, UserInterface, API</td>
</tr>
<tr>
<td>Dashboard-IOT App (msg)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, API</td>
</tr>
<tr>
<td>Dashboard-IOT App real time</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>WS</td>
<td></td>
<td></td>
<td>Dashboard, IOT App, API WS</td>
</tr>
<tr>
<td>Synoptics data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, UserInterface</td>
</tr>
<tr>
<td>My Personal Data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, UserInterface, API</td>
</tr>
<tr>
<td>KPI (metrics) data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, API, SQL calls x Metrics</td>
</tr>
<tr>
<td>Special Widget (complex)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Dashboard, ETL, special, IOT App, API</td>
</tr>
<tr>
<td>Complex Event (msg)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, ETL, special, IOT App, API</td>
</tr>
<tr>
<td>WFS/WMS (GIS data)</td>
<td>Yes</td>
<td>[yes]</td>
<td>[yes]</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Dashboard, GIS tools, or GeoServer, IOT App</td>
</tr>
<tr>
<td>GTFS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>ETL, special [IOT App], MicroApplications</td>
</tr>
<tr>
<td>OD Matrices</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Special tools, MicroApplications</td>
</tr>
</tbody>
</table>
Now, it is more clear about what we intend as: **High Level Types**

<table>
<thead>
<tr>
<th>HLT, High Level Types++</th>
<th>GPS</th>
<th>Static</th>
<th>Dynamic</th>
<th>Single</th>
<th>Time Series</th>
<th>Trajectory</th>
<th>HTTP</th>
<th>How to ingest/change/manage</th>
</tr>
</thead>
<tbody>
<tr>
<td>API (Ext. Srv., any prot.)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>ETL, Special, IOT App, …</td>
</tr>
<tr>
<td>External Service (web pag)</td>
<td>Yes</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>ETL, Special, IOT App, Web Scraper, …</td>
</tr>
<tr>
<td>MicroApplication (webapp)</td>
<td>Yes</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Dashboard, IOT App, API, FTP, …</td>
</tr>
<tr>
<td>Heatmap matrix</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Maps, IOT App, MicroService, UserInterface, API</td>
</tr>
<tr>
<td>Synoptics (group)</td>
<td>Yes</td>
<td>Yes</td>
<td>(Yes)</td>
<td>(Yes)</td>
<td></td>
<td>Yes</td>
<td></td>
<td>Dashboard, Special Tools, IOT App, API, …</td>
</tr>
<tr>
<td>Special Tools (functional)</td>
<td>(Yes)</td>
<td>(Yes)</td>
<td>(Yes)</td>
<td>(Yes)</td>
<td></td>
<td>Yes</td>
<td></td>
<td>As MyPersonalData, …</td>
</tr>
<tr>
<td>Typical Trends (not yet)</td>
<td>(yes)</td>
<td>Yes</td>
<td>(Yes)</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>MicroApp, Special tools, (API) , …</td>
</tr>
<tr>
<td>Traffic Flows (are coming)</td>
<td>(yes)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Maps, Special tools, API, …</td>
</tr>
<tr>
<td>Color Maps</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maps, Tables, Special tool, User Interface, API</td>
</tr>
<tr>
<td>GTFS (see Sensors, POI)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Maps, Special tools, API, …</td>
</tr>
<tr>
<td>Typical Trajectory (MyKPI)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Maps, Special tools, API, …</td>
</tr>
</tbody>
</table>

All of them can be shown on Dashboards, what about manipulate them!!!!
Smart-city Ontology km4city

https://www.snap4city.org/19
IOT Device Model
## IOT Device Data Model (3): Attributes

<table>
<thead>
<tr>
<th>Where</th>
<th>IOT Device Model</th>
<th>IOT Device</th>
<th>A Temporal Instance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOT Broker</td>
<td>Broker: OrionUNIFI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IOT Broker</td>
<td>Protocol: NGSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info</td>
<td>ID: string</td>
<td>ID: “park45”</td>
<td>park45</td>
</tr>
<tr>
<td>Position</td>
<td>GPS: lat, long</td>
<td>GSP Position: 43.12, 11.34</td>
<td>GSP Position: 44.12, 11.12</td>
</tr>
<tr>
<td>Static attribute</td>
<td>Description: string</td>
<td>Description: “parking massaia”</td>
<td></td>
</tr>
<tr>
<td>Static attribute</td>
<td>Location: string</td>
<td>Location: “Via Massaia”</td>
<td></td>
</tr>
<tr>
<td>Static attribute</td>
<td>Civic Number: string</td>
<td>Civic Number: 3</td>
<td></td>
</tr>
<tr>
<td>Static attribute</td>
<td>MaxCapacity: number, cars</td>
<td>MaxCapacity: 456</td>
<td></td>
</tr>
<tr>
<td>Values</td>
<td>dateObserved: Timestamp</td>
<td></td>
<td>23-12-2019T20:13:12...</td>
</tr>
<tr>
<td>Values</td>
<td>FreeSlots: Integer, #</td>
<td></td>
<td>345</td>
</tr>
<tr>
<td>Values</td>
<td>Humidity: float, %</td>
<td></td>
<td>25.5</td>
</tr>
<tr>
<td>Values</td>
<td>Temperature: float, celsius</td>
<td></td>
<td>34</td>
</tr>
</tbody>
</table>
IOT Device Data Model (2)
IOT Device Data Model (1)

- **IOT Broker**
  - Name of the Brokers: among those registered
  - Protocol: NGSI, AMQP, MQTT, etc..
  - Format: CSV, JSON, XML.
  - Service/Tenant:.............
  - ServicePath:.........

- **Info**
  - Name (Identifier)
  - Model: Custom or Model ID
  - DeviceType: ..a string..
  - MAC address: ...optional...
  - Edge-GW: Raspberry, Android, ...
  - Edge-GW: URI
  - Producer
  - Owner
  - Freq: ..... Sec
  - Keys: K1, K2
Data Ingestion and Management
Snap4city Data Ingestion Flow Diagram

Static

- Static or quasi Static
  Data: POI, etc.

- IOT Broker Registration
- IOT Device Model Reg.
- IOT Device Registration

Models

- IOT Directory
  sporadic (1c) static

Dynamic

- IOT Orion Broker
- NGSI

Real Time

- Real Time data in Pull
  Any gateway, server

- IOT Orion Broker
  push

- IOT Devices

- IOT Device
  push

- IOT Brokers

Static

- IOT App
  pull

- NGSI

Information, File

- Snap4City Tools

- IOT Device/Gateways

IOT Apps

SURI Link

Knowledge Base

- Semantic Reasoners

Indexing and Aggregating

- NIFI, Elastic Search

Subscription note

- Real Time
  NGSI

Automatic

- IOT App
  push

- Adapter

Periodic

- IOT Device
  push

- IOT App
  push
Checking data ingestion results

- Data Inspector
- **ServiceMap**, SCAPI
  - LOG / LOD viewer
  - Super Service Map
- IOT Directory
- SCAPI: Swagger
- IOT Broker

- Data Inspector
- **ServiceMap**, SCAPI
- My Data Dashboard (Kibana), DevDash
- Elastic Search

Some functionalities are limited to certain roles.
Data Inspector: all you need to know about data, data sources and ingestion processes
Data Inspector (Digital Twin info) Major Submodels

• Digital Twin
  – Device and sensors data
  – Values
  – Healthiness criteria and values
    • Machine learning tools
  – Images and physical world
  – Licensing
  – Users

• Users
  – Defined the Data and Devices
  – Defined the processes
  – Create dashboards
  – Etc.

• Process Views
  – Device Management tool
  – Data ingestion processes
    • ETL, IOT Apps
  – Data storage access views
    • Index views
    • Relationships view
  – Data Analytics and Transformation
    • IOT App, R Studio, Python
  – Data Rendering Dashboards
    • Synoptics
  – Processes’ Developers
Snap4City (C), May 2021

- Click with the mouse on it

**Knowledge Base view**

Some functionalities are limited to certain roles

HLT: Sensor
• Specific values of selected

• Information of the values of the other sensors on the same device

• View Trends, marking problems, healthiness by point according to a Fuzzy model

• Marking problems for future machine learning processes (separate tool)

Some functionalities are limited to certain roles
Some functionalities are limited to certain roles
HLT: From Dashboard to IOT APP

- Click with the mouse on it

Snap4City (C), May 2021
Business Analysis Dashboards

For all kind of users: DevDash

- Dynamic Filtering, Adaptable, ...
- Full data details, drill down,...
- Synergic with Data Inspector which addresses data relationships, processing and information
- Only Your Data for
  - Manager and Area Managers
- All Accessible Data for
  - ToolAdmin and RootAdmin
• Multi faceted Search by
  • Devices
  • Organization
  • Drill on Time
  • Drill on Map
  • Value Types
  • Data Type
  • Value name
  • Data table
  • Etc.

• Respect Privacy and GDPR
Platform Integration Capabilities
URBAN PLATFORM: SMART CITY IOT AS A SERVICE AND ON PREMISE

IOT APPLICATIONS - INSTANT APPS
- Data Driven Applications
- Real Time Processing
- Batch Processing
- Any Protocol & Format

DASHBOARDS & APPLICATIONS
- Control Room
- Situation Room
- Operator Dashboards
- Business Intelligence
- What-If Analysis
- Decision Support
- Simulations
- Risk Analysis
- Resilience Analysis

MOBILE & WEB APPLICATIONS
- Development Kit
- Suggestions
- Mobile Apps
- Monitoring Panels
- Platform Utilities
- Ready to Use Smart Applications

MICROSERVICES & ADVANCED SMART CITY API
- IoT Directory
- Service Map
- Resource Manager
- Data Gate
- R Studio
- ETL

LIVING LAB - DEV TOOLS - COWORKING
- Test Cases
- Scenarios
- Videos
- Hackathons
- Open Sources
- Community of Cities
- Training Tutorials
- Community Management

BIG DATA - DATA ANALYTICS
- Predictions
- Anomaly Detection
- What-If Analysis
- Traffic Flow Reconstruction
- Origin-Destination Matrices
- Social Media Analysis
- Offer VS Demand Analysis
- Environmental Data Analysis
- Predictions
- Real Time Heatmaps
- Routing
- Alerting
- Early Warning
- Personal and Virtual Assistants
- Smart Solutions
- Smart Sharing
- Participatory

DATA ANALYTICS TOOLS - MICRO-APPLICATIONS
- KM4CITY DATA AGGREGATE KNOWLEDGE BASE - EXPERT SYSTEM OF THE CITY - BIG DATA STORE

IOT MNG - DATA MNG - DATA INSPECTOR - PROCESS MNG - USER ENGAGEMENT - GDPR MNG
Smart City Functional Architecture

Data Sources, External Services
PULL Data

Data Ingestion, aggregation, regularizatio
n, reconcile: IOT Directory, NIFI, special tools

Knowledge base
Semantic Reasoners

Federation
Search and Query, Smart City API, Web Socket Server, GIS, Facet, semantic

Data Analytics, Simulations, Special Tools
R Studio, Tensor Flow, Python, ...

IOT Applications, Business Logic
Node-RED + Snap4City MicroServices

Inform, announce, Act!, warning, alarms, What-IF, ...

Authentication, Authorization, Platform & Processes Management, Data Inspector, Digital Twin, ...

Social Media Crawler and Manager

Back-End

Front-End

Transport systems
Mobility, parking

Public Services, Govern, events, ...

Sensors, IOT Cameras, Wi-Fi

Environment, Water, energy

Shops, services, operators

Social Media
Internal and External Smart City API

https://www.km4city.org/swagger/external/index.html
https://www.km4city.org/swagger/internal/index.html
• Open Data:
  – Data gate, federation of Open Data Portals
  – IOT App, ETL proc (PULL)

• IOT Networks:
  – IOT Application processes, data driven or PULL
  – IOT Brokers (Push) → IOT Shadow

• Web Pages:
  – Web scraping, crawling processes

• Satellite data

• Social media: Twitter, Facebook, ...
  – Twitter Vigilance, IOT App

• Mobile Apps
  – Smart City API

• Files upload: CSV, Excel, etc.
  – IOT Applications, ETL

• REST API, WS, FTP, LD, LOD, etc.
  – IOT Applications, ETL

• Data base accesses
  – GIS: WFS, WMS
  – ETL, IOT Application

Any kind of data and flows
Standards and Interoperability

IOT Network Interoperability
IOT Interoperability


https://www.snap4city.org/65
IOT/IOE Protocols

Communication Patterns

- MQTT
- HTTP(s)
- AMQP
- COAP
- NGSI
- OneM2M
- WebSockets
- Etc.
IOT Network Manager vs Final User

Network of IOT Brokers

Knowledge Base, Km4City

Knowledge and Storage
Data from the Field and City

External

Internal

IOT Broker

IOT Directory

Discovering

Registering

Browsing

IOT Network Manager

My IOT Device

IOT Application

Discovering

Discovering

Prepare

Deep Manage

Exploit

Dashboard Wizard

Final user Manager

Register

Snap4City (C), May 2021

IOT Network Manager vs Final User

Network of IOT Brokers

Knowledge Base, Km4City

Knowledge and Storage
Data from the Field and City

External

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IOT Broker

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Discovering

Prepare

Deep Manage

Exploit

Dashboard Wizard

Final user Manager

Register

Snap4City (C), May 2021
Integration via IoT Apps and processes
IOT Application Listing, they can be

- Basic (white)
- Advanced (red)
- IOT Edge
  - Raspberry Pi
  - Android
  - Win/Linux
- Data Analytic (Plumber)
- Web Scraper (Portia)
Integrated Node-RED development

Event Driven, real time data ingestion
Web Scraping
Automatize:
- Import data from CKAN to Snap4City
- Upload Public Data from Snap4City to CKAN
- Data Harvesting
- Dashboards and Mobile/Web Apps creation
Example of Integrated workflow

OpenMaint: BPM Workflow management, team assignment, material control, ...

Consumptions/productions

Events/actions

Business Intelligence

Maintenance

Dashboards and actions

IOT App, Data event firing, event detection and firing

Critical event management

Snap4City (C), May 2021
• **Snap4City can**
  - Create new tickets
  - Manage steps, workflow
  - Collecting feedbacks and results from teams
  - Manage all phases of the workflow on the fields via IOT Apps and logics
  - The integration if via API and MicroServices into IOT App.
BIM Server


Snap4City (C), May 2021
External REST Call API vs MicroServices

- Each REST Call API can be automatically transformed into a MicroService for the IOT Applications.

https://www.snap4city.org/129
Integration via IoT Apps on IoT Edge
Controlling Energy Power

Measuring Energy Consumption

IOT Edge: Node-RED + Snap4City

Measuring any kind of sensors values

Any kind of notification channel

Contextual (smart city/home) data, Data Analytics
Historical Data, Remote Control, Mobile App

DCS

Administrative Servers

Alexa: Voice Commands

Snap4City (C), May 2021

https://www.snap4city.org/369
Sonoff: Controlling Energy Power
Philips Hue: Controlling Lights
Hue: Motion Control / Alarm
TP Link: Controlling / Measuring Energy Plugs
Alexa: Voice Control

IOT Edge: Raspberry pi: Node-RED + Snap4City
- Controlling Motors
- Controlling Irrigators
- Measuring Temperature and Humidity
- Garage Door
- Window Roller Shutters
- Alarm sound and light

Local Control

Environmental Contextual data from the city
Historical Data, Remote Control, Mobile App

https://www.snap4city.org/620

Snap4City (C), May 2021
IOT Edge Device

Access to IoT Edge Maintenance

IOT Edge:
Node-RED + Snap4City

IOT Brokers

HTTPS

HTTPS

WSs

Firewall Gateway
Towards internet

Other Local Connections

Remote Access/Control/program to your IOT Applications via secure connection

IOT Devices

IOT Brokers

Search and Query, Smart City API
Facet, semantic search

Knowledge base
Semantic reasoners

Indexing and aggregating
Elastic search

Snap4City (C), May 2021
Integration with GIS and ArcGIS

https://www.snap4city.org/drupal/node/368
GIS vs Sna4City

GIS Server can be: ESRI ArcGIS Enterprise, QGIS, GeoServer, ..
GIS Player can be: ESRI ArcGIS Pro, ArcGIS Portal, Snap4City WFS player, ..

- **GIS:**
  - Geographic Information System
- **WMS:**
  - Web Map Service
- **WFS:**
  - Web Feature Services

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**Smart City APIs**

**Big Data and Semantic Storage**

**Data Ingestion**

**WMS/WFS APIs**

**IOT Apps**

**Dashboards and Apps**

**Dashboard System**

**GIS Player**

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Any External Service

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**GIS**

**WFS**

**WMS**

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Press (EA) for more details.
Linked Open Data
Km4City: Knowledge Base

- Multiple DOMAINS
- Geospatial reasoning
- Temporal reasoning
- Metadata
- Statistics
- Risk and Resilience
- Licensing
- Open and Private Data
- Static and Real time
- IOT/IOE

Street-Guide
- Mobility and transport
- Points of interest
- Sensors, IOT, ...
- Energy
- Administration
- Citations from strings

Ontology Documentation:
http://www.disit.org/6506
http://www.disit.org/6507
http://www.disit.org/5606
http://www.disit.org/6461

Big Data Tools
- LOD and reasoners

Schema: http://www.disit.org/km4city/schema
RDF version: http://www.disit.org/km4city.rdf
Views of the Knowledge Base

- How pass from ServiceMap to Linked Open Graph, Linket Data view tool
Linked Open Data

LOG: https://log.disit.org
Integrated command and control center
Command and Control

- **Multiple dashboards**, different features and tools for different users and contexts:
  - decision makers, operators, tablet for operators, mobile phones,...
  - *situation room* with touch screen,
  - *Chat room* for each dashboard, network of dashboards, etc.
  - *Interactive and animated widgets*: custom widgets, dynamic pins,

- **Unique Visual Prog. IoT App**: Business Logic, Integration, Connectors, Data Transform, ....

- **Large range of data, beyond GIS and IoT, also derived data**
  - historical and real time even driven
  - rendering data and acting on the field, actuators, agents, final users, operators..

- **Easy to Reshape, adapt, evolve**: according to the City’s Needs

- **Easy to Add Features**: data analytics, custom modules, integration, interoperable, ....

- **Controlling Control Room, video walls**:
  - automated reconfiguration on the basis of the events
  - passing from operators to wall, etc..
  - Multiple operators stations with multiple monitors
Chemical Plant Dashboard
Green Impact Capacity (GIC)
Altair Control room
Control Room
Video Wall

From Consolle Operator to the Video Wall

e.g. 3x3 (HD)
https://www.snap4city.org/511
Smart City Monitoring: notifications, alerting

Notification with IOT App may
- Fire on any kind of condition exploiting on IOT App logic
- produce messages/events on
  - Facebook, Telegram,
  - SMS, MMS, IOT Devices, ..
  - email, LOGS, FTP, ..
  - dashboards, mobiles, ..
  - Workflow/incident management system for ticketing
- video wall management,
- etc. etc.
BIM view of the Altair Chemical Plant


Snap4City (C), May 2021
scalable smart analytic application builder for sentient cities

fire & snap4city

powered by fiware
THE FIWARE SMART CITIES REFERENCE ARCHITECTURE

SMART CITY GOVERNANCE SERVICES
- Complex Event Processing
- Big Data Algorithms
- AI Algorithms
- Advanced Data Miese
- Operation Dashboards

Processing Engines (Flink, Spark, Hadoop...)
- Wirecloud Mashup
- GIS
- Knowledge BI

COBON CONTEXT BROKER
- STREET
  - Location
  - Traffic
  - Pollution
- PARKING SPACE
  - Location
  - No. Slots
- BUS
  - Location
  - Route
  - Next stop
  - Time next stop
- WASTE BIN
  - Location
  - Capacity
  - Level
  - Threshold
- SHARED CAR
  - Location
  - Status
  - Driver
- CITIZEN CLAIM
  - Location
  - Citizen ID
  - Description

IDAS NGSI AGENT FRAMEWORK
- Alternative IoT Platforms (e.g. OneM2M)
- IoT Agent
- System Adapter
- System Adapter
- System Adapter
- System Adapter

DEPLOYED IoT NETWORKS, CAMERAS, ROBOTS
- CCTV
- ACC
- Sensor
- CRM

OTHER INFORMATION SOURCES
- Social Networks
- ... Other Information Sources

VERTICAL SOLUTIONS
- SDP
- Air Quality
- Public Transport
- Waste Management
- ... Vertical Solutions

OPEN DATA PORTAL (Supporting Real-Time Datasets)
- Date Marketplace (Data Economy Support)

Extended Data Publication Platform (e.g. CKAN)

Snap4City (C), May 2021
• Snap4City - Powered by FIWARE Solution:
    – NGSI V1, V2 The IOT Orion Broker
    – IOT Orion Broker can connect JSON, MQTT, Lightweight M2M, LoraWAN, OPC, SigFOX, etc. see FiWare [https://www.fiware.org](https://www.fiware.org)

• Snap4City - FIWARE Training Services:
  • [https://marketplace.fiware.org/pages/solutions/03bccd83a0e1b0398ba7a0bf](https://marketplace.fiware.org/pages/solutions/03bccd83a0e1b0398ba7a0bf)

• Snap4City - FIWARE Consultancy Services:

• Snap4City is compatible with all the above protocols
  – via IOT Orion Broker,
  – via IOT Applications.
  – via direct connection on ETL processes on their corresponding IOT brokers, and/or

• Snap4City is also compatible with many other protocols, see the table reported in page: [https://www.snap4city.org/65](https://www.snap4city.org/65)
Overview

Acknowledgements
Main running instances

- Sii-Mobility → mobility and transport, sustainability
- REPLICATE → ICT, smart City Control room, Energy, IOT
- RESOLUTE → Resilience, ICT, Big Data
- GHOST → Strategies, smart city
- TRAFAIR → Environment & transport
- MOSAIC → mobility and transport
- WEEE Life → Smart waste, environment
- Smart Garda Lake → Castelnuovo del Garda, SMARTEA
- 5G → Industry 4.0 vs SmartCity
- Green Impact → Industry 4.0, Chemical Plant
- SmartBed (Laid) → smart health
- Green Field Peas (Soda) → Industry 4.0, Chemical plant
- MobiMart and PISA Agreement → data aggregation, mobility and transport, Living Lab
- Lonato del Garda → smart parking, environment
- Herit Data → tourism, culture and management
- ISPRA JRC → site management and services
- Capelon (Sweden) → smart light solutions
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- Km4City is an open technology and research line of DISIT Lab exploited by a number of projects. Some of the innovative solutions and research issues developed into projects are also compliant and contributing to the Km4City approach and thus are released as open sources and are interoperable, scalable, modular, standard compliant, etc.
Overview

- April 2021
Be smart in a SNAP!