Platform Overview
X CINI
February 2021

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES
scalable Smart aNalytic APplication builder for sentient Cities: for Living Lab and co-working with Stakeholders

https://www.Snap4City.org

Platform Overview
X CINI
February 2021

Paolo Nesi, paolo.nesi@unifi.it
https://www.Km4City.org
https://www.disit.org
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

POWERED BY FIWARE

FREE TRIAL

PEN Test Passed

EU GDPR COMPLIANT

100% OPEN SOURCE

Snap4City (C), February 2021
Snap4City (C), February 2021

Concept

Dashboards and Apps

IOT Apps

KPI, POI, MyKPI, ...
API, External Services
Web Scraping

Data Analytics, Artificial Intelligence

WorkFlow

BIM

GIS

Big Data

KB

API, External Services

IOT Broker

LD, LOD

IOT Broker

IOT Broker

IOT Broker

Opernus
Smart City Functional Architecture

- **Transport systems**, **Mobility, parking**
- **Public Services**, **Govern, events**...
- **Sensors, IOT Cameras, Wi-Fi**...
- **Environment, Water, energy**...
- **Shops, services, operators**
- **Social Media**

**Data Sources, External Services**
- **PULL Data**

**Data Sources, Brokers, External Services**
- **Data Driven, Real Time**

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

**Knowledge base**
- Semantic Reasoners

**Indexing and aggregating**
- Elastic Search

**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

**Front-End**
- Rendering
- Acting, Widgets, Synoptics, MicroApps
- User interface, Drill down, maps, heatmaps

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

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

Snap4City (C), February 2021
One Snap4City Platform may serve Multiple Cities
BIM Integration Dashboard

Dashboards

- Firenze traffic: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=OTg5](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=OTg5)
- Firenze air quality: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjU0Mg==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjU0Mg==)
- Alert: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA0OQ==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA0OQ==)
- Capelon: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA2Mg==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA2Mg==)
- Lonato: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjM0Nw==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjM0Nw==)
- Svg: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjk4Ng==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjk4Ng==)
- Svg: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjk0NQ==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjk0NQ==)
- Roma: [https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjcyNg==](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjcyNg==)
Some complete Use Cases
Florence
Smart City Control Room
Florence Metropolitan City

- **Multiple Domain Data**
  - mobility and transport, accidents, public transport, parking, traffic flow, Traffic Reconstruction, ...
  - civil protection, gov data, covid-19, social & social media, people flow, tourism, energy, ...

- **Multiple dash/tool Levels & Decision Makers**

- **Historical and Real Time data**
  - Billions of Data
  - Predictions, what-if analysis

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

- **Since 2017**
Florence Case

- **Smart City Control Room**
- **Dashboards and Services**
- **Mobile App**: Firenze Where What

- **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
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**
- **Historical and Real Time data**
  - Dashboards, What-IF analysis
  - Traffic Flow Predictions,
  - Reconstructions, routing
  - Mobile App, people flows
- **Services Exploited on:**
  - Dashboards, Mobile App
- **Since 2017, 2019**

**Cities:** Firenze, Pisa, Livorno, Modena, Santiago di Compostela

Snap4City (C), February 2021
Traffic Flow Reconstruction for the cities

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

COVID-19 1st phase

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjY1MQ==
What-If Analysis

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

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
People Control on Pub Services

DIGIPOLIS Antwerp

- Multiple Domain Data
  - PAX Counters: museum, pub services, COVID-19
- Multiple Levels & Decision Makers
- Historical and Real Time data
  - 20 fixed PaxCounters
  - 2 Mobile PaxCounters
  - Business Intelligence Dashboards
- Services Exploited on:
  - Dashboards, Mobile Apps, API
  - 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?iddashboard=MTQwNw==
Programmable PAX counting

Mobile PAXCounter 01 in Antwerp

Mon 23 Sep 18:39:46

Begin 3:00
Finish 5:30

Antwerp

Snap4City (C), February 2021
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.

Snap4City User Engagement Antwerp

Data is based on activities performed on Antwerp in a Snap mobile App.
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTcwNg==

Antwerp
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

- Historical and Real Time data
  - Billions of Data
  - Optimized planning on chemical model
  - Business Intelligence on Maintenance data

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

- Since 2020
Sinottico Sintesi Impianto Altair 2

RTO online
Workflow for Ticket management

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

Snapt4City (C), February 2021
Tuscany Region
Firenze, Pisa, Livorno, Prato, etc.
Environment and Quality of Life
Air Quality Predictions

• Multiple Domain Data
  • Traffic Flow data, Pollutant, 3D City structure, weather, ...

• Multiple Decision Makers
  • City officers, energy industries

• Historical and Real Time data
  • Dashboards, What-IF analysis
  • Pollutant Predictions,
  • Traffic Flow Reconstruction

• Services Exploited on:
  • Dashboards, Mobile App

• Since 2020

Snap4City (C), February 2021
• 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
Lonato del Garda
• Multiple Domain Data
  • Smart Parking, Environment, Wi-Fi
• Multiple Decision Makers
  • City Officer, operators
• Historical and Real Time data
  • Dashboards
• Services Exploited on:
  • Dashboards, API
• Since 2019
Smart Light Control of Capelon

- Energy Domain
  - Smart Light
  - FiWare Orion Broker

- Dashboards
  - Map coverage on Sweden
  - Monitoring and real-time control

- Historical and Real Time data

- Services Exploited on:
  - Multiple Levels, API

- 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 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==
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
Prato
Smart City vs Industry 4.0
GIDA set up

ModBus to Snap4City Gateway Edge

5G network devices

Smart City data from many sources

IOT Applications

Dashboards and Apps

IOT Data Shadow Snap4City

Big Data Analytics, Artificial Intelligence

Telemonitoring Telecontrol

Telecontrol
Dubrovnik
People Flows

HeritData Dubrovnik

Dubrovnik
https://www.snap4city.org/4

- 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 (C), February 2021
Develop Mobile & Web Applications
Exploiting Snap4City Smart City Services

Smart City Services

Analysis & Design
- Analysis
- Design
- Data Discovery
- Data Ingestion
- IOT App Development

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

Development
- Deploy
- Testing

Advanced Smart City API and MicroServices
- Snap4City Mobile & Web Apps Development Kit

Mobile and Web Apps
- Application Requirements Analysis
- Application Development
- Publication Production
- Testing

Snap4City (C), February 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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</thead>
<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>
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<tr>
<td>Interactive</td>
<td>Video1</td>
<td>Video2</td>
<td>Video3</td>
<td>Video4</td>
<td>Video5</td>
<td>Video6</td>
<td>Video7</td>
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<td>3:16</td>
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<td>2:00</td>
<td>2:48</td>
<td>2:35</td>
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</table>

https://www.snap4city.org/577
Dashboard and tools Development

On Line Training Material (free of charge)

<table>
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<th>Part</th>
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<th>2nd part (?)</th>
<th>3rd part (?)</th>
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<th>5th part (?)</th>
<th>6th part (?)</th>
<th>7th part (?)</th>
</tr>
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<td>What</td>
<td>General</td>
<td>Dashboards</td>
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<td>Smart City API: Web &amp; Mobile App</td>
</tr>
</tbody>
</table>

PDF

Interactive

Video1

Video2

Video3

Video4

Duration: 235, 316, 340, 200, 248, 235, 147
Dashboard Development

IOT Applications

Knowledge Base, Km4City

Knowledge and Storage Data from the Field and City + MyKPI++

Widget Collection

Dashboard Wizard

Create, save, load, delegate, grant access

Dashboard Editor

External Services

Dashboard Collection

My Own Dash/App

Micro Applications

Custom Widgets/Synoptics

Public Dashboard Collection

Snap4City (C), February 2021
The Wizard helps you in selecting only possible combination of data vs graphic representation.
Dashboard List and Editor
Special Custom Widgets

- Smart parking
- Smart Energy
- Smart Light
- Smart ...
- Energy View
- Custom Controls
Sinottico Sintesi Impianto Altair 2
Alert Registration

Alerting Generation

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

Kind: River Flooding
Severity: Relevant
People Involved: 10
Impact 1: People Disease
Impact 2: Pollutant

City: FIRENZE
Addr: VIA ADRIANO CECCIONI

Registered: Green:1610755283309

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

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

- 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

Snap4City (C), February 2021
Dashboard- IOT App

From Dashboard to IOT App

Nature

MyKPI variable

Synoptics

IOT Application
Dashboard-IOT App

From IOT App to Dashboard

Nature

Snap4City (C), February 2021
IOT Devices

- LoraWAN + Arduino + I2C, NGSI
- Arduino, Wi-Fi, NGSI
- Snap4All IOT Button ESP, NGSI, Wi-Fi, BT
- Snap4All PAX Counter
- LoraWAN WiFi, NGSI, GPS
- Any Sensor / Actuator
- Open to other protocols

IOT Edge Devices

- IOT Edge NodeRED: Raspberry Pi, WiFi, NGSI, RJ45,
- IOT Edge NodeRED: Android, LINUX, Windows,
- LoraWan Gateway: IOT Edge, NGSI, WIFI, RJ45, GPS

Snap4City (C), January 2021
IoT Application Development
smartening the solutions
Data Adapation Transformation, Conversion Integration

Business Logic vs Dashboards Data Analytics control

Everywhere: Cloud, on IoT Edge Devices
Nov. 2020 collection

Two Snap4City Libraries

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

<table>
<thead>
<tr>
<th>Collection</th>
<th>Libraries</th>
<th>Description</th>
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<tbody>
<tr>
<td>Nov. 2020</td>
<td>$S4C$Dashboard</td>
<td>gets other activity on my data</td>
</tr>
<tr>
<td></td>
<td>$S4C$IoT</td>
<td>coordinates from map</td>
</tr>
<tr>
<td></td>
<td>$S4C$LogDev</td>
<td>event log</td>
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<tr>
<td></td>
<td>$S4C$View</td>
<td>show micro web app</td>
</tr>
<tr>
<td></td>
<td>$S4C$Social</td>
<td>twitter last channel</td>
</tr>
<tr>
<td></td>
<td>$S4C$Sigfox</td>
<td>twitter last tweet</td>
</tr>
</tbody>
</table>

We suggest also to install:

- https://flows.nodered.org/search?term=snap4city
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?iddasboard=MzA0OQ==
Flow Mng

Alarm
Ticket Creation
Various Teams

Change Alert Color Status

Dashboard Smart City

Ticket id: alert_160777329679
Last Color Code: Red
Date: Time: 2021-05-09T15:32:00.000Z
Last data time: 2021-05-09T16:37:30.800+02:00
Kind: Fire
Severity: Low
4People: 100
Impact 1: Pollutant
Impact 2: Noise
GPS: 43.776494,11.22879

Florence: Events in the city
Social Events, Traffic Events and Critical Events

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjM1Ng==
Development of Data Analytics
R Studio and Python algorithms are automatically transformed into MicroServices for your IOT Applications
Data Analytics

Characterizing City Areas by User Behavior

Free Parking Predictions

Active on Mobile Apps as:
- "Firenze dove cosa"
- "Toscana dove cosa"

Traffic Flow Reconstruction/prediction

Predicting City Areas Crowd level characterizing Users’ Behaviors

What-IF Analysis

Scalable multiresolution OD matrix

Early Warning Water Bomb

Predicting at EXPO2015

Predicting Pollution

Predicting City Users on Areas

Early Warning Hot in Tuscany

Predicting Traffic Flow

Snap4City (C), February 2021
• 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
Characterizing City Areas

Predicting City Areas Crowd level characterizing Users’ Behaviors

Wi-Fi based
Free Parking Predictions

Careggi car park

<table>
<thead>
<tr>
<th>Model features</th>
<th>BRNN model results</th>
<th></th>
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</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>
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<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

Selector Web

| Firenze   | Firenze + FiPiLi | Pisa   | Santiago | Modena | Livorno | test |

Selector - Map

Last sensors measure 2019-10-14 00:25:14

Traffic Flow Reconstruction

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==
Computation of Traffic Flow Evolution
Florence
Accidents Density

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 further analysis.

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>
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<tbody>
<tr>
<td>What</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 Deployment</td>
<td>Smart City API, Web &amp; Mobi App</td>
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<td>PDF</td>
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<td>Interactive</td>
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<td>Video1</td>
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<tr>
<td>Video3</td>
<td></td>
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<tr>
<td>Video4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>205</td>
<td>316</td>
<td>324</td>
<td>200</td>
<td>246</td>
<td>235</td>
<td>147</td>
</tr>
</tbody>
</table>
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.
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
- .....
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**

- **IOT Device**
  - Sensors/Actuators

- **IOT Edge**
  - IOT Broker

- **Web Scraping**

- **DataGate**

- **GIS data, Maps, ...**

- **API, External Services**
  - Rest Call .......MS

- **External Data Stores**
  - LD, LOD

- **My Files**
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 ...
### HLT, High Level Types++

<table>
<thead>
<tr>
<th></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><strong>POI (Point of Interest)</strong></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><strong>MyPOI data</strong></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><strong>Sensor data</strong></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><strong>Sensor Actuator data</strong></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><strong>MyKPI data</strong></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><strong>Dashboard-IOT App (msg)</strong></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><strong>Dashboard-IOT App real time</strong></td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>WS</td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, IOT App, API WS</td>
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<tr>
<td><strong>Synoptics data</strong></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><strong>My Personal Data</strong></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><strong>KPI (metrics) data</strong></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><strong>Special Widget (complex)</strong></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>
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<tr>
<td><strong>Complex Event (msg)</strong></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><strong>WFS/WMS (GIS data)</strong></td>
<td>Yes</td>
<td>[yes]</td>
<td>[yes]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dashboard, GIS tools, or GeoServer, IOT App</td>
</tr>
<tr>
<td><strong>GTFS</strong></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><strong>OD Matrices</strong></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>

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

<table>
<thead>
<tr>
<th>HLT, High Level Types++</th>
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<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>
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<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>Yes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>Dashboard, IOT App, API, FTP, …</td>
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<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>(Yes)</td>
<td></td>
<td>Yes</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></td>
<td>Yes</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>
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<tr>
<td>Traffic Flows (are coming)</td>
<td>(yes)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Maps, Special tools, API, …</td>
</tr>
<tr>
<td>Color Maps</td>
<td>Yes</td>
<td></td>
<td>Yes</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>Yes</td>
<td></td>
<td></td>
<td>Maps, Special tools, API, …</td>
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<tr>
<td>Typical Trajectory (MyKPI)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Maps, Special tools, API, …</td>
</tr>
</tbody>
</table>

• Now, it is more clear about what we intend as:

--- **High Level Types** ---
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>23-12-2019T20:13:12…</td>
<td></td>
</tr>
<tr>
<td>Values</td>
<td>FreeSlots: Integer, #</td>
<td>345</td>
<td></td>
</tr>
<tr>
<td>Values</td>
<td>Humidity: float, %</td>
<td>25,5</td>
<td></td>
</tr>
<tr>
<td>Values</td>
<td>Temperature: float, celsius</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>
IOT Device Data Model (2)
Data Ingestion and Management
Snap4City Data Ingestion Flow Diagram

Static Models

- Static or quasi Static Data: POI, etc.
- IOT Broker Registration
- IOT Device Model Reg.
- IOT Device Registration

Dynamic Models

- Real Time data in Pull
  - Any gateway, server
  - IOT Device Reg.
- IOT Orion Broker
- IOT App

Time Series

- IOT Devices
- IOT Brokers
- IOT Orion Broker
- IOT App
- Adapter

Knowledge Base

- Semantic Reasoners

Indexing and Aggregating

- NIFi, Elastic Search

Information, File
- IOT Apps
- Snap4City Tools
- IOT Device/Gateways
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
• Click with the mouse on it

Knowledge Base view

Some functionalities are limited to certain roles
Business Analysis Dashboards
For all kind of users: DevDash

• Dynamic Filtering, Adaptable, ...
• Full data details, drill down,...
• Synergetic 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
Platform Integration Capabilities
Smart City Functional Architecture

Transport systems
Mobility, parking

Public Services, govern, events, ...

Sensors, IOT Cameras, Wi-Fi

Environment, Water, energy

Shops, services, operators

Social Media

Data Sources, External Services
PULL Data

Data Sources, Brokers, External Services
Data Driven, Real Time

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

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

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

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

Back-End

Front-End

Rendering
Acting, Widgets, Synoptics, MicroApps
User interface, Drill down, maps, heatmaps
• 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
IOT Network Interoperability
IOT Interoperability

• 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

BIM Integration Dashboard


Snap4City (C), February 2021
Integration via IoT Apps on IoT Edge
Measuring any kind of sensors values

Controlling Energy Power

Measuring Energy Consumption

IOT Edge: Node-RED + Snap4City

Local Control

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

Alexa: Voice Commands

Any kind of notification channel

DCS

Administrative Servers

ODBC

SCADA

Modbus

OPC UA

Alexa

Wi-Fi

Snap4City

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

IOT Edge: Raspberry pi: Node-RED + Snap4City

Measuring Temperature and Humidity
Garage Door
Window Roller Shutters
Alarm sound and light
Controlling Motors
Controlling Irrigators

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

https://www.snap4city.org/620

Snap4City (C), February 2021
IOT Edge Device

Access to IoT Edge
Maintenance

IOT Edge: Node-RED + Snap4City

Other Local Connections

HTTPS

HTTPS

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

http://www.disit.org

IOT Devices

IOT Brokers

IOT Brokers

HTTPS

HTTPS

HTTPS

Firewall
Gateway
Towards internet

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

Search and Query, Smart City API
Facet, semantic search

Knowledge base
Semantic reasoners

Indexing and aggregating
Elastic search
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

GIS Player

Dashboards and Apps

Data Ingestion

WMS/WFS APIs

Smart City APIs

Big Data and Semantic Storage

GIS and WFS

GIS Player

Dashboard System

Any External Service

Big Data Analytics, Artificial Intelligence

IOT & Real Time Streams

IOT Apps
API, and Federation of Smart Cities via API
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.
Federation of Snap4City vs IOT ORION Broker

- IoT Agent
- crate-db 4200:4200
- MongoDB 27017:27017
- IoT Orion Broker 8668:8668
- Quantum Leap 8668:8668

Federation

SSM2ORION

SUPER

Dashboard Builder

Snap4City Solutions

Hybrid Solutions

NGSI

Area 3
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

**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
Smart-city Ontology km4city

https://www.snap4city.org/19
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

Schema: http://www.disit.org/km4city/schema
RDF version: http://www.disit.org/km4city.rdf
Linked Open Data

LOG: https://log.disit.org
How to Add on Features on Platform: capability and constraints
Adding new Features

- Dashboard Features --> Custom Widgets, Widgets
- Connectors, adapters, IoT protocols, data transformations, etc. --> by creating new MicroServices, new flows or new IoT Apps ...
- Applications, Modules --> for management, for verticals, in the core by using
- IoT Devices --> for collecting new data kind or acting on the field
- Processes --> Data Analytic of any kind, also exploiting machine learning, gpu, etc.
- Web and Mobile Apps --> new end-users services
- Dashboards
- IoT Applications
- Data ingestion process, integration, etc.
- External Services to be exploited on Dashboards
- etc. etc.
Adding new Features

• Dashboard Features --> Custom Widgets, Widgets
  • they can be created by using the Custom Widget SVG approach
    • TC1.22a: Create and configure a Snap4City SVG Custom Widget for real-time interaction
    • TC1.22b: Create and configure a Snap4City SVG Custom Widget for real-time interaction
    • Custom Widgets: Table explanation, as SVG
    • TC1.26: Use customised SVG pins in a map
    • TC9.19: Custom Widgets / Synoptics controlled by IOT Applications
  • they can be created by developing new elements programming in PHP, JavaScript, Angular, D3, etc..
    • Custom Synoptics and Widgets for Dashboards

• connectors, adapters, IoT protocols, data transformations, etc. --> by creating new MicroServices, new flows or new IoT Apps ...
  • https://www.snap4city.org/download/video/course2020/di/
  • HOW TO: Develop an IOT Application for Data Ingestion
  • they have to be in Node.JS, JavaScript according to Node-RED
    • Snap4City Supported Protocols, adding new protocols
    • how to create a flow and nodes in Node-red: https://nodered.org/docs/creating-nodes/first-node
  • They can be automatically created from API rest call
    • TC2.25. Registering external MicroService calling RestCall services, using it on IOT applications
    • business logic behind a dashboard
    • TC9.19: Custom Widgets / Synoptics controlled by IOT Applications
Adding new Features

• Applications, Modules --&gt; for management, for verticals, in the core by using
  • any language you prefer, preferably exposing API for integration with other modules
    • [https://www.km4city.org/swagger/external/index.html](https://www.km4city.org/swagger/external/index.html)
    • [https://www.km4city.org/swagger/internal/index.html](https://www.km4city.org/swagger/internal/index.html)
  • See Tutorial on how to transform any REST API in a MicroService
    • TC2.25. Registering external MicroService calling RestCall services, using it on IOT applications

• IoT Devices --&gt; for collecting new data kind or acting on the field
  • HOW TO: add a device to the Platform
  • HOW TO: Manage IOT Network Components on Snap4City
  • you can add to the platform any kind of IoT Device, with any kind of IoT Protocol
  • You can exploit the open source for Android and raspberry for creating your safely connected IoT device with Snap4City using NGSI V1, V2 and exploiting our secure communication approach

[https://www.snap4city.org/692](https://www.snap4city.org/692)
Adding new Features

- **Processes -- Data Analytic** of any kind, also exploiting machine learning, gpu, etc.
  - see tutorial on Data Analytics
- **Web and Mobile Apps** -- new end-users services
- **Dashboards: Dashboard Builder and Kibana**
- **IoT Applications in Node-RED**
- **data ingestion process, integration, etc.**
- **External Services to be exploited on Dashboards**
  - by simply registering their URLs on the portal
  - [https://www.snap4city.org/55](https://www.snap4city.org/55)
- **Workflows:** via OpenMaint
  - TC 1.24 – Integrated Ticketing and Facility Management system
- **BIM models** via Bim Editor for IFC production → Bim Server
  - HOW To: Manage BMP and BIM: main features of openMAINT, BMP, BIM
  - etc. etc.
• new version modules
  – to be integrated in the main version, have to be tested and validated by DISIT Lab. They have to:
    • be in Affero GPL
    • do not affect the functionalities of other modules in negative manner
    • provide the needed quality, in terms of test cases, documentation, etc.
  – If they are not part of the core,
    • can be based on proprietary model, and exploit the Snap4City tools via APIs
      – no constraints
    • but forked, they need to te published version on Internet and linked to main according to Affero GPL.
• Snap4City modules are mainly in Affero GPL
  – platform rebranding is not allowed
Integrated command and control center
Chemical Plant Dashboard

Altair Control room

Green Impact Capacity (GIC)
Control Room
Video Wall

From Consolle Operator to the Video Wall

e.g. 3x3 (HD)

Snap4City (C), February 2021
DASHBOARDS in Snap4City
Kibana vs Snap4City DashBoard Builder
Two Main Lines for Dashboarding are present

- **Dashboard Builder of Snap4City**
  - For accessing and browsing data on: Elastic Search, Mongo, MySQL, Smart City API, Super and thus from federated Smart City API, etc.
  - Supports sensors/actuators: data driven data, maps in extended manner, data driven widgets, large collection of widgets, direct IoT Connections, custom widgets, animated PIN on maps, a large set of panel/widgets, etc.
  - Very simple to be used for control room, decision makers, situation rooms, operators, etc.
  - Very well integrated with IoT App, Custom widgets, animation, external services.
  - Very simple to be customized for non programmers since all the tools are visual.
  - Support for GDPR and deep control of access.
  - Can integrate Kibana/Grafana Views into a Widget

- **Kibana** (so called DevDash, AMMA and recently My Dashboard (Dev) Kibana), also accessible as Grafana
  - For accessing and browsing data on Elastic Search storage and other sources supported
  - No Support for real time event driven widgets/panels, actuators and synoptics, no sophisticated maps, etc.
  - Not simple for control room, decision makers, etc.
  - Not integrated with IoT App, Custom widgets, animation, external services.
  - Oriented to developers, complex production of custom views, etc.
  - Partial support of GDPR and deep control of access.
Snap4City Dashboard Builder vs Kibana

<table>
<thead>
<tr>
<th>Features</th>
<th>Snap4City Dashboard Builder</th>
<th>Kibana, Grafana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Collection of Widgets</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Custom Widgets SVG of any kind</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Real time event driven widgets and data</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Business Logic for data transformation with visual programming</td>
<td>YES</td>
<td>Some coding</td>
</tr>
<tr>
<td>Maps with custom PIN, bubbles, animated and moving, etc.</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Maps with paths, shapes, traffic flow, scenarios, routing, heatmaps, ...</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Maps with orthomaps from WFS, GIS connection, etc.</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>TV camera integration and selection</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Widgets for business logic integration on real time: buttons, selector, switch, etc.</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Kiviat, Spider net</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Typical Time Trends: day, week, .....</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Time Trend Compare</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Selectors/Menus: text, icons, etc.</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Full control of graphic layout, font, colors, refresh per widget, etc.</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Iframe integration of third party widgets and web pages, nesting dashboards</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Connection among multiple Dashboards and Widgets</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Synchrononization with Video Wall, and Operators Views</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Multiseries, barlines, charts, pie, donut, simple selectors, trends, multitrends, etc.</td>
<td>YES</td>
<td>Limited</td>
</tr>
<tr>
<td>Single content, string, html, any data, etc.</td>
<td>YES</td>
<td>Limited</td>
</tr>
<tr>
<td>Special widgets: Weather forecast, civil protection, road plates, Twitter, etc...</td>
<td>YES</td>
<td>Nothing</td>
</tr>
<tr>
<td>Faceted search</td>
<td>possible with selectors</td>
<td>YES</td>
</tr>
</tbody>
</table>
SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

TOP

FIWARE & Snap4City

FROM CITY DASHBOARD TO APPLICATIONS
FORGING & MANAGING OPEN AND FLEXIBLE WEB AND MOBILE APPS
IOT APPLICATIONS VS IOT EDGE DEVICES
IOT APPLICATIONS, THE LOGIC AND THE SMARTNESS
ADVANCED SMART CITY API, MICROSERVICES, SNAPACITY API
SNAPACITY FOR BEGINNERS
DATA USAGE, RESILIENCE, SNAPPY AND SIMULATION
SNAPACITY LIVING LAB FOR COLLABORATIVE WORK
SNAPACITY ARCHITECTURE AND ECOSSYSTEM, OPENED TO DEVELOPERS AND STAKEHOLDERS
SNAPACITY AND SNAPACITY PROJECTS
SNAPACITY THE VIEW OF THE ADMINISTRATORS
TWITTER VIGILANCE SOCIAL MEDIA ANALYSIS
DECISION SUPPORT SYSTEM AND OUR ROADMAP
HOW TO ADOPT SNAPACITY, AND OUR ROADMAP
SNAPACITY (C), February 2021
http://www.disit.dinfo.unifi.it
http://www.disit.org
DISIT Lab, Distributed Data Intelligence and Technologies
Distributed Systems and Internet Technologies
Department of Information Engineering (DINFO)
http://www.disit.dinfo.unifi.it
http://www.disit.org

Snap4City (C), February 2021

Concept

Dashboards and Apps

IOT Apps

Data Analytics, Artificial Intelligence

WorkFlow

KPI, POI, MyKPI,...
API, External Services
Web Scraping
BIM

IOT Broker

IOT Broker

BIM

GIS

LD, LOD

Big Data

KB

API, External Services

KPI, POI, MyKPI,...
Snap4City IoT Registration and Access

A range of IoT Brokers and protocols

A range of other data sources
Federation of Snap4City vs IOT ORION Broker

IoT Agent -> Quantum Leap -> IoT Orion Broker

Crate-DB 4200:4200 -> 8668:8668

MongoDB 27017:27017 -> 4041:4041

Federation

SSM2ORION 8668:8668

SUPER 1026:1026

Dashboard Builder

Hybrid Solutions

Snap4City Solutions

NGSI

Area 3
**SMART CITIES REFERENCE ARCHITECTURE**

- Is open to the Development of Applications leaving large space to developers
- Is centered on the Orion Broker that results central in the architecture: any Broker or data source is sending data to the Orion
- Data shadow for historical data with external data base as CrateDB on which you can attach Kibana
- **Security level** is based on TLS. User management partially demanded to developers
- Visual Flexible IOT processing is not clearly provided
- **Limited API** for smart city, API IOT data access mainly
- Limited data modelling for smart city, powerful on IoT
- **Knowage BI** presents several limitations in showing Smart City Data
- **Market place** on Open Data
- Support of Developers via Fi-Ware
- Deployed as VM and Dockers
- open source, not the applicative parts

**VS**

- Is open to the Development of Applications leaving large space and providing a **large set of ready to use applicative tools** and solutions to build their solutions on top or aside.
- Is fully distributed, **any kind of data source** can be ingested, automatically to form the Data Shadow.
- **Orion Broker is only one of the Brokers** that can be used. It can be also protected by Snap4City tech, with Mutual Authentication
- **Visual Flexible IOT processing is provided** as IOT App that is Node-RED plus Snap4City MicroServices suites
- **Advanced Smart City API** are provided on top of Knowledge Base
- **Dashboard Builder** has been designed for Smart City Data and automated dashboards’ production
- **Storage** based on Elastic Search + Kibana or HBase/Phoenix
- **Market Place** for promoting, publishing and sharing Open Data, tools, processes, experiences
- Passed PEN test, GDPR compliant, **published security** on IEEE Access
- **Interoperable** with huge number of protocols and formats
- Full Support for **Living Lab** of the city, coworking, tutorials
- Fully support for **Multi-tenancy**
- Fully support **federation of smart cities, smart factories**
- Deployed as VM and Dockers, on cloud and on premise
- 100% open Source, including the management and applicative aspects
Installing Snap4City

https://www.snap4city.org/471

To get an updated version read it!
Acknowledgements
DISIT lab roadmap vs model and tools’ usage

2013
- Km4City Ontology 1.1
  - Tuscany, Road Graph
  - Mobility
  - culture, tourism
  - Events
  - Parking
  - Services
  - Linked open graph

2014
- Weather Forecast
- Real Time Wi-Fi
- Entertainment
- LOD
- Twitter Vigilance
- Social Media Analytics, Sentiment Analysis

2015
- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

2016
- Smart Energy
- Sustainable Mobility
- Control Room
- Dashboard

2017
- Origin-Destination and trajectories
- Traffic Reconstruction
- Offer Analysis
- OBU, smart devices

2018
- User engagement
- Bike Sharing
- Data Analytics ++
- Social Predictions
- OBD2

2019
- Traffic and Mobility Impact on Pollution
- NOx predictions

2020
- Mobility Demand / Offer Analytics and Strategy

Km4City
- SII-MOBILITY SCN
  - Infomobility
  - Mobile App
  - Routing
  - Multimodality

- GHOST SIR
  - Sardinia Region
  - Smart City Strategies and plan

SNAP4city
- IOT/IOE
- Smart City IOT
- GDPR, Privacy & Security
- Green Impact
- Mobility Demand / Offer Analytics and Strategy
- Industry 4.0
- Critical Plant
- Monitoring
- GDPR, Privacy & Security
- Green Field Peas Soda4.0
- Industry 4.0
- PCP Award
- Smart Lonato
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http://www.disit.org

Roadmap

2019
- European Open Science Cloud
- Smart Bed
  - Smart Health
- Green Field Peas
  - Industry 4.0
- bee smart city
  - Smart Lonato del Garda

2020
- CAPELON
  - Smart Light
  - Sweden
- Smart Mobility
  - PISA, PUMS
  - Living lab
- Interreg Mediterranean
  - Smart Tourism
  - 6 Pilots
  - Data Analytics
  - Extended platform
- Km4City 1.6.7

2021
- enelx
  - Winner of Open Data Challenge
- AMPERE (2021-22)
  - Industry 4.0
- Smart Ambulance (2021-22)
- Enterprise (2021-22)
  - Industry 4.0
- Industry 4.0 (2021-22)

2022
- PC4City (2020-21)
  - Monitoring Terrain
- Smart Lonato del Garda
- ReverbEnet (2021-22)

Winner of Open Data Challenge
PC4City (2020-21)
Monitoring Terrain
AMPERE (2021-22)
Industry 4.0
Smart Ambulance (2021-22)
Enterprise (2021-22)
Industry 4.0 (2021-22)
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, Occitanie (Fr)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Venezia area (I)
- WestGreece area (Gr)
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
Acknowledgements

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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.
Be smart in a SNAP!

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100% OPEN SOURCE

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