LIVING LAB

Snap4City System and Deploy

October 2020, Course
https://www.snap4city.org/577

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

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

October 2020, Course
https://www.snap4city.org/577
Main Organizations/areas

- Antwerp area (Be)
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- DISIT demo (multiple)
- Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Helsinky 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)
Free Trial

• Register on [WWW.snap4city.org](http://WWW.snap4city.org)
  – Subscribe on DISIT Organization

• You can:
  – Access on basic Tools
  – Access to a large volume of Data
  – Create Dashboards
  – Create IOT Applications
  – Connect your IOT Devices
  – Exploit Tutorials and Demonstrations

IF you need to go more in deep you can ask us to pass at the next Role becoming full AreaManager with full rights of development, also for Data Analytics, machine learning, etc.
## On Line Training Material (free of charge)

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https://www.snap4city.org/577
General Overview of the full Course

• **1st part:** General Overview
• **2nd part:** Dashboards Creation and Management
• **3rd part:** IOT Applications development, IOT Devices, IOT Networks
• **4th part:** Data Analytics, in R Studio, in Python, how to Exploit and Manage Data Analytics in IOT Applications
• **5th part:** Data Ingestion, Data Warehouse, Data Gate, IOT Device Data ingestion, IOT App for Data Ingestion, etc.
• **6th part:** Snap4City Architecture, How To Install Snap4City
• **7th part:** Smart city API (internal and external) Web and Mobile App development tool kit

A number of the training sections include exerctations

Updated versions on: [https://www.snap4city.org/577](https://www.snap4city.org/577)

See also courses in ITALIANO: [https://www.snap4city.org/485](https://www.snap4city.org/485)
6th part Agenda

• Snap4City Architecture
• Smart City in a Snap, How to become smart
  – Smart City Development Life Cycle
  – Analysis and Design for Innovation (Co-Creation and Co-Working)
  – Analysis for Innovation, the workshops for innovation, co-creation; Data Discovery
• Snap4City: Overview of Development Tools
  – How to Add Functions that are not present in the Platform
• Snap4City: Smart City IOT as a Service vs Consulting and Developing
• Snap4City vs Fi-Ware
• Snap4City vs State of the Art Solutions
• Snap4City Living Lab For Collaborative Work
• Snap4City Services: Snap4City vs Snap4Industry 4.0
• Installing Snap4City
• The view of the Administrator
  – Monitoring Resource Consumption and Traffic
  – Managing and Monitoring Data Traffic in the BackOffice
  – Auditing Activities
  – Managing Back Office processes via Containers
• Acknowledgement
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

Living Lab - Dev Tools - Coworking
- IOT Directory
- Service Map
- Resource Manager
- Data Gate
- r Studio
- ETL

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 and Predictions
- Real Time Heatmaps
- Routing
- Alerting
- Early Warning
- Personal and Virtual Assistants
- Smart Solutions
- Smart Sharing
- Participatory

Data Analytics Tools - Micro-Applications

KM4CITY DATA AGGREGAT KNOWLEDGE BASE - EXPERT SYSTEM OF THE CITY – BIG DATA STORE

IOT MNG - DATA MNG - DATA INSPECTOR – PROCESS MNG – USER ENGAGEMENT – GDPR MNG ...

GEO | CITY UTILITIES | OPEN DATA | LEGACY & EXTERNAL SERVICES | PERSONAL DATA | IOT / IOE | BROKERS | KPI | INDUSTRY 4.0 | SOCIAL MEDIA
Snap4City: Builder of Sentient Cities Solutions

Dashboards with data driven IOT Applications enforcing intelligence

IOT and data World

IOT Applications

Dashboards and Apps

My IOT Devices

Big Data Analytics, Artificial Intelligence
Snap4City Architecture: V1

Data Sources, External Services
- Pull Data

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

Data Ingestion, aggregation, regularization, reconcile
- NIFI
- Tools, [ETL], DISCES, IOT Apps

Big Data Cluster
- HDFS, Hbase, Phoenix

Knowledge base
- Semantic reasoners

Search and Query
Smart City API
- Facet, semantic search

Indexing and aggregating
- Elastic search

Data Analytics
- R, Tensor Flow, Python, MapReduce, ...

Visualization Analytics
- Visual

IOT Applications
- Node-RED + Snap4City MicroServices

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

Rendering Acting, Widgets, MicroApps
- User interface, Interactive Dashboard, Drill down, maps, heatmaps
Smart City Functional Architecture, V1

Data Sources, External Services
PULL Data

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

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Search and Query, Smart City API
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Rendering Acting, Widgets, MicroApps
User interface, Interactive Dashboard, Drill down, maps, heatmaps

IOT Applications
Node-RED + Snap4City MicroServices

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

Public Services, Govern, events, ...

Sensors, IOT Cameras, Wi-Fi

Environment, Water, energy

Shops, services, operators

Social Media

Social Media Crawler and Manager
Snap4City Architecture, V2

Data Sources, External Services
PULL Data

Data Ingestion, aggregation, regularization, reconcile:
NIFI, IOT App

Back-End
- Knowledge base
  - Semantic reasoners
- Indexing and aggregating
  - Elastic search
- Search and Query
  - Smart City API
  - Facet, semantic search
- Data Analytics, Simulations
  - R, Tensor Flow, Python, ...
- IOT Applications, Business Logic
  - Node-RED + Snap4City MicroServices

Front-End
- Rendering
  - Acting, Widgets, MicroApps
- User interface
  - Interactive
  - Dashboard, Drill down, maps, heatmaps

Inform, announce, Act!, warning, alarms, What-IF, ..
Smart City Functional Architecture, V2

Transport systems
Mobility, parking

Public Services,
Govern, events, ...

Sensors, IOT,
cameras, Wi-Fi ...

Environment,
Water, energy

Shops, services,
operators

Social Media
Crawler and
Manager

Data Sources, External Services
PULL Data

Data Ingestion,
aggregation, regularization, reconcile:
NIFI, IOT App

Knowledge base
Semantic reasoners

Indexing and aggregating
Elastic search

Search and Query,
Smart City API
Facet, semantic search

Data Analytics, Simulations
R, Tensor Flow, Python, MapReduce, ...

IOT Applications, Business Logic
Node-RED + Snap4City MicroServices

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

Rendering
Acting, Widgets, MicroApps
User interface,
Interactive
Dashboard, Drill down,
maps, heatmaps

Snap4City (C), October 2020
Standards and Interoperability


https://www.snap4city.org/65
Unique of Snap4City Platform (1)

- **Data ingestion and model**
  - **Unified data model** (exploited in the Wizard and Knowledge base)
  - **Semantic Reasoner** modelling city entities, supporting semantic search, expert system, digital Twin, etc.
  - **IOT Directory** abstracting complexity of IOT Devices, Edge, Brokers, protocols and data formats

- **Data Analytics and Data Processes**
  - **Flexible and extensible IOT Applications**
  - **Data Analytic**: multiple programming languages,

- **Visual Analytics, dashboarding, Apps**
  - **Wizard**: expert system for immediate dashboard production matching data vs graphics representation
  - **Dashboards specialized** multidomain for Smart Cities
  - **Custom Widgets and Synoptics**
  - **Ready to use Mobile App, instant App, MicroApplication**
  - **Strategies** formalization supports
Unique of Snap4City Platform (2)

• Openness to any developers
  – Living Lab support for coworking, sharing, and delegating
  – Advanced Smart City APIs and MicroServices
  – 100% Open Source, Open hardware

• Security and Privacy
  – End-2-end encrypted communication, on devices, platform, ... dashboards
  – GDPR compliant privacy/security

• Non functional
  – on cloud and on premise, your private installation
  – Ready to use Appliance Virtual Machines and/or Containers for a modules and tools.
  – Flexible, Modular, Elastic, scalable and robust
Snap4City - scalable Smart aNalytic APPlication builder for sentient Cities

Smart Cities need to set up a flexible Living Lab to cope with the city evolution in terms of services and city users’ needs and sustainability. Snap4City solution provides a flexible method and solution to quickly create a large range of smart city applications exploiting heterogeneous data and enabling services for stakeholders by IoT/IIoT, data analytics and big data technologies. Snap4City applications may exploit multiple paradigms as data driven, stream and batch processing, putting co-creation tools in the hands of: (i) Smart Living Lab users and developers a plethora of solutions to develop applications without vendor lock-in nor technology lock-in, (ii) final users customizable / flexible mobile Apps and tools, (iii) city operators and decision makers specialized / sophisticated city dashboards and IoT/IIoT applications for city status monitoring, control and decision support. Snap4City satisfies all the expected requirements of Select4Cities challenge P2P and much more, and it is 100% open source, scalable, robust, respects user needs and privacy; provides MicroServices and easily replaceable tools, compliant with GDPR, provides a set of tools for knowledge and living lab management, and it is compliant with standards like FI-WARE and others.
How to adopt Snap4City

On your premise

Download and deploy

Installation on your premise
• Virtual Machines or Dockers
• Different configurations
  • From small to scalable
  • Exploiting your legacy tools
  • Interoperable with any tool
• No vendor lock-in, No tech lock-in

Mixed solutions! For example:
• Start on Cloud as Smart City as a Service
• Migrate on premise on the fly
• Start on Cloud into a sand box
• Pass to install on premise what you need

Smart City as a Service
• Supporting Org
• 100% Open Source Platform: Github
• Further developments
• Publishing Appliances and Dockers
• Training courses, docs
• Consulting
• Forums
• Etc.

https://www.snap4city.org

Snap4City (C), October 2020
Living Lab Accelerating

GO!

Community Building

City Operators

Resource Operators

agreements

networking

tutorials

documentation

Inhouse companies

Tech providers

experiments

workshops

Category Associations

Corporations

Advertisers

City Users

subscription to applications

personal services

Manage Apps & Dashboards, User Engagement

Upload context Open Data

Connect IOT/IOE

Connect external Services

Data Ingestion and Analytic algorithms

Advanced Smart City API, MicroServices

Produce City IOT Applications & Dashboards

Produce Apps and Dashboards for City Users

Monitor City Platform

Promote Applications & Dashboards

Help desk

partnerships

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Advertisers
Develop Mobile & Web Applications Exploiting Snap4City Smart City Services

![Diagram showing the development process of mobile and web applications exploiting Snap4City Smart City Services.

- **Analysis & Design**:
  - Analysis
  - Design
  - Data Discovery
  - Data Ingestion

- **Data Analytics**:
  - Data Analytics Development
  - IOT App Development
  - Dashboard Development
  - Special Tool Development

- **Advanced Smart City API and Microservices**:
  - Snap4City Mobile & Web Apps Development Kit
  - Application Requirements Analysis
  - Application Development
  - Deploy
  - Testing
  - Publication

- **Deployment**:
  - Deployment
  - Testing
  - Publication

- **Smart City Services**

- **Mobile and Web Apps**

Snippet of text:

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

Data Analytics
- Data Analytics Development
- IOT App Development
- Dashboard Development
- Special Tool Development

Advanced Smart City API and Microservices
- Snap4City Mobile & Web Apps Development Kit
- Application Requirements Analysis
- Application Development
- Deploy
- Testing
- Publication

Deployment
- Deployment
- Testing
- Publication

Smart City Services

Mobile and Web Apps
```
Smart City in a Snap Acceleration for Innovation

• Organization/City analysis
  – requirements analysis, identification of domains
  – Snap4City Innovation Process → Report of Scenarios vs Data
  – Data Analysis → Report as Data Table

• Smart City Design for Innovation:
  – Design of main Scenarios and Tools (Dashboard, SCCR, Apps, IOT Network, new data, etc.) → Report as Mock-up Design

• Next phases
  – Data Ingestion and Data Warehouse
  – Scenarios Implementation
Smart City in a Snap
How to become smart
Smart City Development Life Cycle
Development Life Cycle
Smart City Services

Analysis
- Requirements Specification

Design
- In/Out
- Historical Data
- Private Info
- Web Data
- Functional

Analysis and Design
- Analytical
- Visual Interface

Discovery
- ServiceMap
- Data Inspector

Data Ingestion & Modeling
- IOT Directory for IOT Device Regs.
- Data Gate/ETL
- External Services
- MyKPI Modeling
- Web Scraping

Develop. Data Analytic
- R-Studio
- Python
- Java, …

Data Flow Development
- IOT Directory MS
- Search/Store MS
- Ext. Services MS
- Utilities MS
- MyKPI, Per. MS
- WebScraping MS
- Functional MS
- Data Analytics MS
- Dashboard MS
- IOT App Widgets

Development, Deploy, Testing
- Deploy, Testing

User Interface Development
- Dashboard Builder & Wizard
- IOT App Widgets
- Custom Widgets
- Regular Widgets

Dev. Special Tools
- WebScraping MS

Legenda
- phase
- Formal Design
- Tool/Process
- MicroService/Node
- Widget

Snap4City (C), October 2020
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

Deployment
- Deploy
- Publication Production
- Testing

Smart City Services

Mobile and Web Apps

Snap4City (C), October 2020
Analysis and Design for Innovation (Co-Creation and Co-Working)
Development Life Cycle
Smart City Services

Analysis & Design
- Analysis
- Design

Data Discovery

Data Ingestion

IOT App Development

Data Analytics Development

Special Tool Development

Dashboard Development

Deploy
- Publication Production
- Testing

Testing

Deployment

Publication

Production

Deployment

Deploy
Analysis & Design for Innovation

• Analysis
  – The analysis starts with a number of meetings/interviews with stakeholders
  – The identification of the target stakeholders/actors/users (target Segments) and their definition/description
  – The meetings/workshops are focused on filling the Snap4City Innovation Matrix which is a evolution of the INNOVATRIX approach of IMEC
  – See the schema of the Snap4City Innovation Matrix reported in the next slide, on the basis of the kind of Meeting for example: (a) starting a smart city, (b) starting a smart city Living Lab

• Data Discovery
  – Production of the Data Table (Snap4City)
  – Data discovery is performed on analysis of the: (i) identified scenarios, (ii) data of the stakeholders, (iii) international sources, (iv) Snap4City experience, etc.
  – Performed by following the Snap4City guidelines on Data Search on web and world.

• Design
  – Focused on creating a large number of Use Cases and/or Scenarios for development
  – The design starts by taking into account the Snap4City development life cycles and tools. Thus shortening all the boring activities and following the typical Snap4City rapid prototyping described in these slides!!
### Snap4City Innovation Matrix and Process

#### Snap4City Innovation Matrix

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<tr>
<td>Value Proposition (Current)</td>
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<td>Future State</td>
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<td>Value Proposition (Future)</td>
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<td>Solution</td>
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<tr>
<td>Barriers</td>
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</tbody>
</table>

#### Design Scenarios

- Analysis Matrix
- Data Discovery
- Design Scenarios

Snap4City (C), October 2020
Analysis for Innovation
Snap4City Analysis for Innovation

• **Analysis**
  – The analysis starts with a number of meetings/interviews with stakeholders
  – The identification of the target stakeholders/actors/users (target Segments) and their definition/description
  – The meetings/workshops are focused on filling the **Snap4City Innovation Matrix** which is an evolution of the INNOVATRIX approach of IMEC
  – The schema of the **Snap4City Innovation Matrix** is reported in the next slide,
    • It may be different depending on the kind of action: (a) starting a smart city, (b) starting a smart city Living Lab, (c) both actions at the same time.

• **Two main goals:**
  – Data Discovery (see later)
  – Identification of User Cases, Scenarios (see later)
• Defined by IMEC for Living Lab according to ENOLL

<table>
<thead>
<tr>
<th>Customer Segment</th>
<th>What customer segments to focus on? What are key characteristics? What is the use-context?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs</td>
<td>What are the needs of the customer segment? How do we prioritize these needs?</td>
</tr>
<tr>
<td>Current Practices</td>
<td>Who or what are competitors, alternatives, customer behavior? What are the pains and gains of these current practices?</td>
</tr>
<tr>
<td>Value Proposition</td>
<td>What (measurable) impact will you create for this customer segment?</td>
</tr>
<tr>
<td>Solution</td>
<td>What are the components of your (digital) solution? How do these components differ for the different customer segments?</td>
</tr>
<tr>
<td>Barriers</td>
<td>What are the barriers for adoption, usage and market entry?</td>
</tr>
<tr>
<td>Value Capture</td>
<td>What value (monetary and non-monetary) do I receive in return? What price should I set (and how)?</td>
</tr>
<tr>
<td>Key Partners</td>
<td>Who are your key partners? How to interact with stakeholders?</td>
</tr>
</tbody>
</table>
Why Innovation Fail....


- Many innovate and good products failed on conquering the market/deploy, due to the psychology of behaviour change.
  - To understand why may fail is the first step.

- One aspects is the **Psychological bias**:
  - Current users overvalue the benefits of what they are using
    - *endowed effect*, which is estimated to be of the 100%.
      The new should be at least twice better than the current to convince to change.
    - *status quo effect*, if the ownership of the current has been for long time (years) it may need a factor of 4 to change.
  - Developers overvalue the benefits of what they have developed, of a factor of 3
Reasons to remain vs change

- Attractiveness of the product
  - Is subjective as perceived value
- They compare the new with respect to what they know
  - Any improvement is a Gain, any lack is seen as a Loss
  - Where losses have a larger appearance of gains
- Cost to change product in:
  - Learning, Time and Money
- Rational vs Irrational impulse to change/buy
  - \( \rightarrow \text{Is a Recipes for a disaster} \)

### The Trade-offs

<table>
<thead>
<tr>
<th>Innovation</th>
<th>What Consumers Gain by Buying</th>
<th>What Consumers Lose by Buying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric cars</td>
<td>Clean environment</td>
<td>Easy refueling</td>
</tr>
<tr>
<td>Digital video recorders</td>
<td>Easy recording</td>
<td>Ability to play rented movies</td>
</tr>
<tr>
<td>DVD rentals by mail</td>
<td>Broad selection</td>
<td>Spontaneity</td>
</tr>
<tr>
<td>E-books</td>
<td>Easy portability</td>
<td>Durability</td>
</tr>
<tr>
<td>Online grocery shopping</td>
<td>Home delivery</td>
<td>Ability to select freshest products</td>
</tr>
<tr>
<td>Satellite radio</td>
<td>Broad selection</td>
<td>Free music</td>
</tr>
<tr>
<td>Screw-top wine caps</td>
<td>Loss spoilage</td>
<td>Elegance of the experience</td>
</tr>
<tr>
<td>Segway scooter</td>
<td>Mobility</td>
<td>Health benefits of walking</td>
</tr>
<tr>
<td>Wind turbines</td>
<td>Nonpolluting energy</td>
<td>Unobstructed views</td>
</tr>
</tbody>
</table>

**CONSUMERS ARE USUALLY**
- skeptical about a new product's performance,
- unable to see the need for it,
- satisfied with the existing product, and
- quick to see what they already own as the status quo.

**COMPANIES ARE OFTEN**
- convinced the innovation works,
- likely to see a need for the product,
- dissatisfied with the existing substitute, and
- set on viewing the innovation as the benchmark.
The 4 Categories

• **Easy Sells/Accept**
  – Acceptance high but new benefits low

• **Sure Failures**
  – Limited benefits and high changes, hard to be accepted

• **Long hauls, a marathon**
  – May be great new value, but associated with big changes. Consumer resistance is high. It may take time to go (e.g., Linux, mobile phones).

• **Smash hits**
  – Are those that have the major probability to be accepted in short or long term.
  – High benefits and innovations, with limited changes in behaviour
The Workshops for Innovation, Co-Creation
Pre-Conditions

• Motivations identified: domains/thematic-areas, actors/segments,
  – e.g.: Mobility and transport, energy, security, environment, etc.

• The customer Segments describe the position of the different Actors Categories with respect to the same needs, problem, action, scenario..
  – Two examples:
    • the Citizens/Tourists would like to have an overview of what is going on in the area, while the City Officials would be afraid to provide too much information since some information can be sensitive to security issues.
    • the Mobile App users would have this and that….., and the City App Provider would monitor their movements to provide ads, etc.
Schedule of Workshops and activities

• **1st Workshop** finalized to
  – definition of the first version of the *Snap4City Innovation Matrix (Report)*
  – Identification of the *Data Table*

• **Intermediate work on**
  – Knowing the *ICT* infrastructure and viable solutions
  – Refining *Data Table* details by email
  – Improving the *Report* with more descriptive scenarios
  – Presenting *Report* and TABLE 1 week in advance wrt the 2nd workshop (if it is possible)

• **2nd Workshop** finalized to
  – Discussing a reasoned version of the scenarios with problems pending
    • Solving pending aspects of the *Snap4City Innovation Matrix and Data Table*
  – **Identification of the main Scenarios to be developed and feasible according to feasibility and priority**
    • Corresponding consolidation of the development teams

• **Conclusive work on**
  – Refining Data Table details
  – Creating Final Report with Descriptive Scenarios
  – Designing of the Minimum Snap4City architecture to cope with scenarios, scenario feature table wrt to Snap4City modules
  – Development of mock-up for Dashboards with fake data to show the concept

• **Final Meeting**
  – Presentation of the final report with: 1 mock-up of a scenario, early design of the Snap4City solution vs modules according to the scenarios
  – further discussion on the next steps

Snap4City (C), October 2020
<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Commons</strong></th>
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<tbody>
<tr>
<td>Needs</td>
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</tbody>
</table>
Meeting Organization

For each table:

- Experts of the domain specific
- Experts of different customers segment
- Operative people
- ICT people
- Decision Makers
- Etc.
Data Discovery and Analysis
Development Life Cycle
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
- Publication Production

Deploy
• Performed by analyzing data from:
  I. identified scenarios from the Snap4City Innovation Matrix
  II. main organizations (via interviews)
  III. other stakeholders (via interview and web pages)
  IV. regional, national and international sources:
      I. open data portals, weather sources,
      II. IOT networks, etc. via web pages and sites
  V. Mobile Applications (via Snap4City API)
  VI. Snap4City portal [https://www.snap4city.org](https://www.snap4city.org)
  VII. etc.

• Exploiting Snap4City experience, data and tools
• By following the Snap4City guidelines on Data Search on web and world reported in the training course and on Snap4City.org portal.
Development Life Cycle
Smart City Services

Analysis & Design

Analysis
Design

Data Discovery
Data Ingestion

Data Analytics

Data Analytics Development
Special Tool Development
Dashboard Development

IOT App Development

Deploy
Publication Production
Testing

Deployment
Data Ingestion

• For Data Warehouse mechanisms (IOT App, IOT Brokers, ETL, DataGate, etc.) and related tools please see slides of the 5th PART of the Snap4City course.
Snap4City Overview of Development Tools
Snap4City: Builder of Sentient Cities Solutions

Dashboards with data driven IOT Applications enforcing intelligence

IOT and data World

IOT Applications

Dashboards and Apps

My IOT Devices

Big Data Analytics, Artificial Intelligence
Development Life Cycle
Smart City Services

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

Data Analytics
- Data Analytics Development
- Special Tool Development
- IOT App Development
- Dashboard Development

Development
- Deploy
- Testing
- Publication Production

Special Tool
- Development

Smart City Services
- Snap4City (C), October 2020
- Development Life Cycle
- 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

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

Data Analytics
- Data Analytics Development
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Development
- Deploy
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Smart City Services
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- http://www.disit.dinfo.unifi.it
- http://www.disit.org
• Open Data:
  – Data gate, federation of Open Data Portals
  – ETL processes (PULL)
  – IOT Application processes

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

• Web Pages:
  – Web scraping, crawling processes

• 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

SNAP4City (C), October 2020
IOT Network Manager vs Final User

Network of IOT Brokers
- Knowledge Base, Km4City
- Network of IOT Brokers

IOT Broker
- Registering
- Browsing

IOT Directory
- Discovering

IOT Application
- Discovering

Final user Manager
- Register

My IOT Device
- Dashboard Wizard

Knowledge and Storage Data from the Field and City

Snap4City (C), October 2020
IOT Application Editor
Developing IOT Applications

MicroServices collections

My IOT Applications

IOT App. Editor

Generating IOT App With Dashboard

Sharing/saving reusing IOT App

Resource Manager

ServiceMap Discovery

Dashboard Collection, Editor and Wizard

Knowledge Base, Km4City

Snap4City (C), October 2020
Web Scraping

My Scraping processes

Web Scraper PORTIA

Generating WEB Scraping

Sharing/saving reusing Scraping

Resource Manager

IOT App. Editor

Knowledge Base, Km4City
Integrated DataGate/CKAN
Static open data ingestion

Federated Crawling
Federated Distribution

Data Set:
- Search
- Loading
- Download
- Share
- Publish
- Also automated

Automated data regularization
Data Ingestion via Data Gate

Knowledge Base, Km4City

Knowledge and Storage Data from the Field and City

Federated Network

Data Gate

Data Set: sharing, Harvesting, Loading/Downloading

Data Set: sharing, Loading, Download, Share, Publish, Also automated

Snap4City (C), October 2020
Batch Processing for dynamic data ingestion
Developing ETL, Data Manager

ETL Process

Resource Manager

DISCES scheduler production

ETL Development Environment

Data Gate

Distributed Back Office

Knowledge Base, Km4City

Data and Storage Data from the Field and City

Knowledge and Storage Data from the Field and City

Data sources

Load data or prepare for data ingestion

Schedule Execute

Saving / Sharing reusing

Data Set Loading/ Downloading
Resource Manager: public and sharing
Data Gathering and Knowledge Management

- Data ingestion can be performed by using multiple tools:
  - ETL processes, IOT Applications, Data Gate, WebScraping. We suggest:
    - ETL for static / periodic data in PULL
    - IOT App for real time data and flow, from IOT Brokers/Devices
    - DataGate for Static Data, upload them as files, or collected from other CKAN
    - WebScraper for scraping data from Web Pages, when authorized!

- See how to test cases:
  - HOW TO: add data sources to the Snap4City Platform
  - HOW TO: define privacy rules for personal data, produced by the end-users own device
  - US6. Developing and using processes for data transformation
  - TC6.1 - Managing DataSets via DataGate: ingest, search, download, upload, annotate, share
  - TC6.3 - Creating ETL processes for automated data ingestion and data transformation
  - TC6.5 - Managing Heterogeneous File Ingestion via ETL processes
  - TC6.9 - ETL processes for multiprotocol and format data ingestion, see on GITHUB for library
  - TC9.2 - Managing heterogeneous File Ingestion, protocols, formats via IOT applications, and open standards
• **Snap4City is interoperable with**
  - ESRI ArcGIS Enterprise, Portal, Pro/MAP, ...
  - other GIS tools supporting WFS, WMS, GeoJSON, GML

• **Snap4City is interoperable since:**
  - **Provides** info/data in WFS, WMS
  - **Exploits** data/info from WFS, WMS
  - **Import** data/info from WFS/WMS

• The Snap4City platform can be installed on premise using **Snap4City Appliance**
  https://www.snap4city.org/471
  - **StartSNAP4CITYVM** includes the Dashboard Builder that is capable to work with WFS WMS protocols for the integration with GIS platforms as ESRI ArcGIS, QGIS, directly or using **Snap4City GIS player**.
  - **KBSSMVM** includes the Smart City API and WFS API which can be used to data harvest from any GIS servers and GIS desktop tool

Snap4City (C), October 2020
Linked Open Graph

LOG: https://log.disit.org

Schema: http://www.disit.org/km4city/schema
RDF version: http://www.disit.org/km4city.rdf
Development Life Cycle
Smart City Services

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

Data Analytics
- Data Analytics Development
- Special Tool Development
- IOT App Development
- Dashboard Development

Development
- Deployment
- Testing
- Publication Production
Data Analytics Dev. in R Studio and/or Tensor Flow

[Diagram showing R Studio and related tools like Swagger, SPARQL, FLINT, Knowledge Base, Km4City, LOG.disit.org, Big Data Store Facility, Smart City API from Knowledge Base and other tools, Creating MicroServices, Saving / Sharing reusing, Resource Manager, Using them into IOT Applications]
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 MicroServices
- Using them into IOT Applications
- Saving / Sharing reusing
- Coding Testing
- Resource Manager
Data Analytics Development in Java

Smart City API from Knowledge Base and other tools

Ontology Schema
LOG.disit.org
Knowledge Base, Km4City
Big Data Store Facility

Swagger
SPARQL, FLINT

DISCES scheduler
Distributed Back Office

Coding
Testing

Monitoring

Resource Manager

Saving / Sharing resusing

Data sources

Snap4City (C), October 2020
Loading new Node-RED nodes/microservices from external Palet

• Ask to RootAdministrator to have your custom Node-RED nodes/modules added to your IOT Applications
  – [https://www.snap4city.org/drupal/contact](https://www.snap4city.org/drupal/contact)
• A validation of requested Node-RED nodes will be performed to avoid violation of security and privacy for all
• Administrators may load custom Node-RED nodes/modules
• This limitation is not present in your on premise installations of Snap4City
Dashboard List and Editor

Snap4City (C), October 2020
Dashboard List and Editor

Snap4City (C), October 2020

Dashboard List and Editor

Snap4City

User: root@localhost, Org: none
Role: Root/Admin, Level: 1

Dashboards
- My Dashboards
- Notifier
- IoT Applications
- My Personal Data
- IoT Devices and Data Collection
- Knowledge and Maps
- Micro Applications
- External Services
- Data Set Manager: Data Gate
- Resource Manager: Process Loader
- Development Tools
- Management
- Settings
- User Management and Auditing
- Help and Contacts
- Documentation and Articles
- My Profile
- Snap4City portal
- Km4City portal
- DISIT Lab portal

Dashboards

DataCenter

DataCenter Energy Consumption

DataCenter gas and smoke (desktop)

DataCenter gas and smoke (mobile)

FirenzeWiFi

Florence data overview

Leonardo - Smart city data 2

My data and trends

My data trends

Notifier monitoring

Flea Real Time Data

Real Time Sensors via ServiceMap3D

Welcome to the Snap4City dashboard editor. This tool allows you to manage and create dashboards for various applications, including DataCenter, DataCenter Energy Consumption, DataCenter gas and smoke, FirenzeWiFi, Florence data overview, Leonardo - Smart city data, My data and trends, My data trends, Notifier monitoring, Flea Real Time Data, and Real Time Sensors via ServiceMap3D.
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
The Wizard help you in selecting only possible combination of data vs graphic representation
Dashboard Development

Widget Collection

Dashboard Editor

Dashboard Wizard

Create, save, load, delegate, grant access

IOT Applications

Knowledge Base, Km4City

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

Micro Applications

External Services

Custom Widgets/Synoptics

Public Dashboard Collection

My Own Dash/App
Developing new Dashboard Graphic Widget

• The development of new Widget is feasible for programmers
  – in PHP, JavaScript and CSS
    • The starting point is the Core Snap4City Virtual Machine Appliance StartSNAP4CITYVM: https://www.snap4city.org/471
    • While the source code is also accessible on GitHub/DISIT
    • see TC3.11 - New graphics widget can be easily created, Dashboard Widget Creation
  – creating a new Graphic widget via SVG and programming: Custom Synoptics and Widgets for Dashboards https://www.snap4city.org/504
1. Create and Load a Custom SVG
2. Select/Reuse an SVG
3. Make and Instance of Synoptic by Associate Variables with MyKPI
4. Create on Dashboard a Widget based on Synoptic HLT such as Ext. Srv.: 
Special Custom Widgets

- Smart parking
- Smart Energy
- Smart Light
- Smart ....
- Energy View
- Custom Controls
From-To Custom Widgets / Synoptics to Storage in WS

MyKPI

Sensor

New Shared Variables

Constant Values

MyKPI

Sensors

Snap4City (C), October 2020
Dashboards

- **Suitable** as: City Dashboard, App interface, and Control Room Dashboards, Situation Room Dashboard, Operator Dashboard
- **Created** visually compounding graphic Widgets
  - Each widget has an autonomous update
  - Each metric/data-source may have associated with an alarm: blinking and sending events to people and machines in different manners
- **Can be**: public or private, private dash can be delegated or passed in ownership
- See the following tutorials
  - **HOW TO**: create a Dashboard in Snap4City
  - **US1.** Using City Dashboards
  - **US2.** Using and Creating Snap4City Applications with Dashboards
  - **US4.** Creating City Dashboards and related Event Monitoring and Actions
Level 1 Users: using dashboards

- **TC1.3.** Accessing and using Dashboards with any device
- **TC1.4.** Dashboards Showing Data Real Time and Historical/trends, comparison
- **TC1.5.** Dashboards showing a range of different High Level Types: KPI, POI, IOT dev, MicroApp, Maps using different kind of Graphics Widget. Monitor city status with Dashboards
- **TC1.6.** Dashboards using different kind of graphics Widgets matching with High Level Types, Monitor city status with Dashboards
- **TC1.12.** Dashboard with MicroApplications
- **TC4.1.** Dashboard and Notificator
- **TC4.6.** Dashboard with city events, ESB, police, traffic, etc.
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 Development
- Dashboard Development
- Special Tool Development

Data Analytics
- Deploy
- Testing
- Data Analytics Development

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

Mobile and Web Apps
- Deploy
- Testing
- Publication Production

Deploy
- Publication Production
- Testing

Testing
- Analysis & Design
- Data Analytics
- Advanced Smart City API and MicroServices

Publication Production
- Analysis & Design
- Data Analytics
- Advanced Smart City API and MicroServices

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

Application Development
- Deploy
- Testing
- Publication Production
Developing Web and Mobile Apps, MicroApps,

Mobile Apps

Web App HTML5, MicroApplications

Embed into Web pages

Advanced Smart City API

Knowledge Base, Km4City

Snap/Km4City Open Source development tool kit

Mobile Application Monitoring Administrator

Swagger

DataInspector

City User

Developer

ServiceMap

Snap4City (C), October 2020
How to Add Functions that are not present in the Platform
Living Lab Accelerating

GO!

Community Building

City Operators

agreements

collaborations

subscription to applications

personal services

Manage Apps & Dashboards, User Engagement

Manage Apps & Dashboards, User Engagement

City Platform

Monitor City Platform

Upload context Open Data

Connect IOT/IOE

Connect external Services

Data Ingestion and Analytic algorithms

Advanced Smart City API, MicroServices

Produce City IOT Applications & Dashboards

Produce Apps and Dashboards for City Users

City Operators

Resource Operators

networking

tutorials

documentation

Inhouse companies

Tech providers

workshops

experiments

Category Associations

Corporations

Help desk

Case Studies

Research groups

Start-ups

Early Adopters

Licensing, Gold services

partnerships

events

Large Industries

Hackathons

Advertisers

City Users

Large Industries
Development Life Cycle
Smart City Services

Analysis & Design
- Analysis
- Design
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Data Analytics
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- Special Tool Development

Development
- Deploy
- Testing
- Publication Production

Snap4City (C), October 2020
Adding a Function that is not present on the platform

• Snap4City allows the Area Managers to Develop new functions for:
  – Interacting with the field: IOT Sensors/Actuators, IOT Devices
  – Data production by using: IOT Devices, IOT Brokers, ..
  – Data Ingestion/Transformation by using: ETL, IOT Applications, WebScraper, DataGate
  – Data Analytics by using: R Studio, Java, C++, Python
  – Data Rendering on Dashboards: PHP, HTML5/JavaScript, Web App, etc.
  – User interaction and App: Mobile App, MicroServices, Dashboards
Snap4City: Smart City IOT as a Service
Smart City IOT as a Service

- Snap4City applications may exploit multiple paradigms as data driven, stream and batch processing, putting co-creation tools in the hands of:
  - **Smart Living Lab** users and developers a plethora of solutions to develop applications without vendor lock-in nor technology lock-in,
  - **final users** customizable / flexible mobile Apps and tools,
  - **city operators** and decision makers specialized / sophisticated city dashboards and IOT/IOE applications for city status monitoring, control and decision support.

Open to Organizations

- Training and manuals: [https://www.snap4city.org/108](https://www.snap4city.org/108)
- Help Desk: [https://www.snap4city.org/3](https://www.snap4city.org/3)
- SLA: [https://www.snap4city.org/497](https://www.snap4city.org/497)
- Terms of Use: [https://www.snap4city.org/drupal/legal](https://www.snap4city.org/drupal/legal)

Snap4City (C), October 2020
Snap4City as Smart City IOT as a Service for

- **Who would like to create** Living Labs as community exchanging experience with other cities as well;

- **Research Institutions, Departments** and **Projects** which would like to perform research and experiments in the area of Smart City and IOT, without the needs of setting up the infrastructure, exploiting open data, collaborating, accessing to Data Analysis on demands, etc. This is the spirit of **EOSC**, European Open Science Cloud Marketplace at which Snap4City is registered as DISIT Lab, see [EOSC].

- **Public Administrations**, as small cities that would like to offer smart services and does not have economic power to manage service on their premise from them self.
Help Desk and SLA

• [https://www.snap4city.org/drupal/contact](https://www.snap4city.org/drupal/contact)

• Bug Reporting
  – [https://docs.google.com/forms/d/e/1FAIpQLSfDQtKqgLIllyycNXiazeYEh1SsRG1YL8Ze4ThD8nZoA5jsoXw/viewform](https://docs.google.com/forms/d/e/1FAIpQLSfDQtKqgLIllyycNXiazeYEh1SsRG1YL8Ze4ThD8nZoA5jsoXw/viewform)

• For Service Level Agreement see:
  – [Service Level Agreement](https://www.snap4city.org/3)

• Help Desk and Contact:
  – [https://www.snap4city.org/3](https://www.snap4city.org/3)

• Availability rates:
  – [https://www.snap4city.org/388](https://www.snap4city.org/388)
Providing consulting, customization, training, and developments

- Snap4City solution can be installed on premise and one cloud, private and public.

- Snap4City, Snap4 SRL, provide support, if needed, for design and/or Develop:
  - Training and tutoring;
  - Smart city infrastructure and architecture;
  - data analytics, that could be developed as proprietary solution for the customer;
  - data ingestion processes, to enable them to have data into the platform;
  - adaptor for some specific protocol or legacy/third part Tool, that we prefer to release as open source, but if the connection is with some proprietary tool, the buyer could be interested to keep these solutions as private;
  - IOT devices, full solutions, dashboards, specific dashboard widgets, etc.
TOP

FROM CITY DASHBOARD TO APPLICATIONS

DATA GATHERING AND CITY DATA KNOWLEDGE MANAGEMENT

IOT APPLICATIONS VS IOT EDGE DEVICES

IOT APPLICATIONS, THE LOGIC AND THE SMARTNESS

ADVANCED SMART CITY API, MICROSERVICES, SNAP4CITY API

SNAPACITY LIVING LAB FOR COLLABORATIVE WORK

SNAPACITY FOR BEGINNERS

SNAPACITY ARCHITECTURE AND ECOSYSTEM, OPENED TO DEVELOPERS AND STAKEHOLDERS

SIMULATION

SYSTEM AND CITY RESILIENCE

SNAPACITY AND Snap4City PROJECTS

TWITTER VIGILANCE SOCIAL MEDIA ANALYSIS

TO ADOPT CITY AND ROADMAP

SNAPACITY THE VIEW OF THE ADMINISTRATORS

Snap4City vs FiWARE

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

Snap4City (C), October 2020
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

Living Lab - Dev Tools - Coworking
- IoT Directory
- Service Map
- Resource Manager
- Data Gate
- R Studio
- ETL

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
- Predicting
- Real-Time Heatmaps
- Routing
- Alerting
- Early Warning
- Personal and Virtual Assistants
- Smart Solutions
- Smart Sharing
- Participatory

KM4City Data Aggregation Knowledge Base - Expert System of the City – Big Data Store

IoT MNG - Data MNG - Data Inspector – Process MNG – User Engagement – GDPR MNG...

- GIS
- City Utilities
- Open Data
- Legacy & External Services
- Personal Data
- IoT / IOT
- Brokers
- KPI
- Industry 4.0
- Social Media
SMART CITIES REFERENCE
ARCHITECTURE

- Is open to the Development of Applications leaving large space to developers
- Is centered on the Orion Broker that result central in the architecture: any Broker or data source is sending data to Orion
- No data shadow at the beginning, only recently they are adding data shadow on IOT Broker
- Security level is not clear, partially demanded to developers
- Visual Flexible IOT processing is not clearly provided
- Limited API for IOT data access
- 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 application 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
- Market Place for promoting, publishing and sharing Open Data, tools, processes, experiences
- Full Support for Living Lab of the city, coworking, tutorials
- Deployed as VM and Dockers, on cloud and on premise
- Fully support for Multi-tenancy
- 100% open Source
• **Comparison:** [https://www.snap4city.org/467](https://www.snap4city.org/467)

• **Snap4City is an official Fi-Ware Solution via**
  – NGSI V1, V2 The IOT Orion Broker
  – IOT Orion Broker can connect JSON, MQTT, Lightweight M2M, LoraWAN, OPC, SigFOX, etc. see Fi-Ware [https://www.fiware.org](https://www.fiware.org)

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

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


https://www.snap4city.org/65
• In Snap4City you can chose to connect your devices at Snap4City Platform in different manners:
  – (a) directly to Snap4City: IOT App, Brokers, MyKPI, etc., or
  – (b) via an IOT Orion Broker (external IOT Broker or those provided by Snap4City), or
  – (c) via any third party IOT Brokers in any protocol you have.

• Snap4City has
  – Improved IOT Orion Broker with the so called Orion Broker Filter (Orion Broker Filter, NGSI Security Wrapper) which is a secure wrapper for NGSI V1 and V2 protocol for enforcing Mutual Authentication, Security, roles, etc.
  – Produced open hardware and open software NGSI Compliant: as
    • IOT Devices with mutual authentication and security based for NGSI on: Android, Arduino and ESP32, IOT Button, etc.
    • IOT Edge devices with mutual authentication and security based for NGSI on: Raspberry PI, Windows, Linux.
Snap4City vs State of the Art Solutions
## Market Solutions

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<th></th>
<th>OT Discovery Abstraction</th>
<th>Security end-to-end, secure on IoT and Dashboards</th>
<th>Open HW and Open SW</th>
<th>Security end-to-end, secure on IoT and Dashboards</th>
<th>Data Type: IOT Devices, IOT Data, Dashboard, Data</th>
<th>Data Type: Publish/subscribe, Delegation, Consent and change</th>
<th>Data Type: Download and Delete</th>
<th>Auditing on Data Type Access</th>
<th>Open Source end-to-end</th>
<th>Scalability IOT</th>
<th>Visual Programming end-to-end</th>
<th>Advanced Smart City API, Microservices</th>
<th>Multi Domain Semantic Platform</th>
<th>Standard based Modules and IOT, Open Devices</th>
<th>Resource Sharing</th>
<th>Data Analytics Integrated</th>
<th>Dashboard 24/7, protected connection</th>
<th>Multi-protocol on IOT</th>
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Smart City Process

- Many aspects should be taken into account for a successful Smart City transformation

  - The influence of each of them depends on context, attitude of the institutions, internal structure, etc.
    - Parallel actions can conflict, compete …
    - Spreading of efforts may distance the goals
    - ……

  - The process may become sustainable, harmonized and faster with a Living Lab Strategy and Support
The Living Lab Concepts and Organization
Snap4City has been Created to satisfy requirements of:

• **ENOLL**: [https://www.openlivinglabs.eu/](https://www.openlivinglabs.eu/)
  – European Network of Living Labs

• **EIP-SCC**: European Innovation Partnership on Smart Cities and Communities
  – [https://eu-smartcities.eu/](https://eu-smartcities.eu/)

• **Select4Cities**: Pre-Commercial Procurement Project to develop a data-driven, Internet-of-Everything (IoE) platform for large-scale urban co-creation
  – [https://www.select4cities.eu/](https://www.select4cities.eu/)
1° place award to

UNIVERSITY OF FLORENCE - DEPARTMENT OF INFORMATION ENGINEERING

for SNAP4CITY

https://www.snap4city.org/558

CERTIFICATE OF ACHIEVEMENT

for successfully completing the SELECT for Cities PCP competition
19.11.2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688196

DIGIPOLIS
FORUM VIRIUM HELSINKI
CITY OF COPENHAGEN
Buyers Group
The Living Lab
Snap4City Tools
Snap4City: Living Lab supporting tools

- All 100% Open Source
- Snap4City web portal
  - Scenarios with ready to use solutions
  - Organization and co-working support
  - Developing tools and Documentation, training, tutorials, HOW TO...
  - Self Assessment tools to monitor your progresses to get suggestion
  - Virtual Assistant: to get help 24/7
- Developing tools
  - All of them are Web-Based developing tools (except for the Mobile App on Android and iOS)
- Resource Manager for Sharing:
  - experiences, data warehouse tools, IOT Applications, Data Analytics, etc.
- Hackathons:
  - IOT Apps, Dashboards, Mobile Applications, Data Analytics, etc.
MultiOrganization, Groups and Profiles

Organizations may have their distinct:
- menus and functionalities, GeoArea, Data, Dashboard, Groups of users, managers, Knowledge Base, repositories, etc.

Users may:
- Have personal IOT Devices/Models, Data, IOT brokers, Dashboards, IOT App,..
- Have access to multiple Groups of Multiple Org.
- Delegate them in usage or access
- Change ownership and Clone to pass a copy
- Assesses their usage and themselves, share
Level 1 Users: creating dashboards

See how Dashboards can be created using the wizard: dashboards with selectors, time trends, maps, etc.

- TC1.8. Visual production of Dashboard via Wizard
- TC1.9. Search on Wizard for any kind of data managed into the platform, from POI to sensors, KPI, social, etc.
- TC1.10. Dashboard delegation to access, and passage of ownership, and/or cloning
- TC1.11. IOT Discovery, on Dashboard Wizard
- TC1.13. Dashboard Builder External Services and Widgets
### TC1.8 - Visual production of Dashboard via Wizard

<table>
<thead>
<tr>
<th>Test Case Title</th>
<th>TC1.8 - Visual production of Dashboard via Wizard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
<td>As any user I can</td>
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<td>- Create a Dashboard, composing it on the basis of data vs widgets, with a large collection of data kind and corresponding graphics widgets, including: map, table, graphs, timetrend, weather, and many special widgets.</td>
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<td>- Modify an available Dashboard, editing general information and widgets, via Dashboard Builder.</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>The user is registered and logged in the system</td>
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<td>Using a PC or Mobile with a web browser.</td>
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<td>Access to the Dashboard Builder.</td>
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<td><strong>Expected successful result</strong></td>
<td>See changes performed on the modified dashboard. Your user account into the Dashboard Builder has been endowed of a number of dashboard for using them, changing them without problem for the system.</td>
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<tr>
<td><strong>Steps</strong></td>
<td>See the created dashboard and play with them.</td>
</tr>
</tbody>
</table>

#### Example 1: Creating a City Dashboard

The creation of dashboards has been strongly simplified with the introduction of matching dashboards vs graphics representation, thus arriving at creating our first dashboards.

You can start testing this requirement by following the sequence of actions:

1. Enter in the main application [https://main.snap4city.org](https://main.snap4city.org) and login:
   - Main --- dashboards
2. On the left column main menu click on Dashboards item. The preview of the dashboards available for the user will be shown.
3. The Dashboards page shows the preview of dashboards created by the user (identified as “My own”), public dashboards accessible only in view, private dashboards that the user cannot access, as he has been delegated by the original dashboard owner, and also eventual dashboard someone that someone has delegated to you.

---

All Text on the Portal are Hypertext with Links for navigation among major concepts
For the user: different levels of engagement

• **Manager: Final Users**
  – Level 1: create Dashboards
  – Level 2: create Dashboards that get and produce data, act on city
  – Level 3: add your own IOT Device, create Dashboards with them and city data
  – Level 4: create IOT Applications to make smarter your Dashboards, services, notifications, exploiting MicroServices

• **Area Manager: Developers, Researchers, Operators (Level 5):**
  – Developer of complex services exploiting: R Studio, ETL, External Services, ...
  – Creating: MicroApplications, MicroServices, web and mobile application exploiting Advanced Smart City APIs, ...
For the user: different levels of engagement

• Multiple Organizations
• Roles:
  – Managers
  – AreaManagers (developers): special access to computing resources
• Levels for self-assessment
  – Suggestions on next steps to learn on the basis of personal progresses
Help Desk and SLA

- https://www.snap4city.org/drupal/contact
- Bug Reporting
  - https://docs.google.com/forms/d/e/1FAIpQLSfDQtKqgLLllyycNXiazeYErh1SsRG1YL8Ze4ThD8nZoA5jsoXw/viewform
- For Service Level Agreement see:
  - Service Level Agreement
- Help Desk and Contact:
  - https://www.snap4city.org/3
- Availability rates:
  - https://www.snap4city.org/388
Resource Manager: public and sharing
Living Lab
Snap4City Hackathons
SNAP4CITY HACKATHON
BUILD YOUR APP FOR A CONNECTED CITY

Open from
Jan 21 - Mar 15

CLICK HERE TO SEE THE HACKATHON WINNERS

see interim winner Fast Rabbit
Validation with developers

- Helsinki and Antwerp, plus Florence Training, CINI Challenge, ..
- 65 performed operational activities:
  - dashboards, IOT Applications, registering IOT devices, etc.
  - More than the 80% created both Dashboards and IOT Applications, thus validating the solution and the process of engaging them in working on the platform

### The 65 users

<table>
<thead>
<tr>
<th></th>
<th>left on platform</th>
<th>Average per day over last 90 days</th>
<th>Total activity 90 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of IOT Applications</td>
<td>117</td>
<td>81,6</td>
<td>7341</td>
</tr>
<tr>
<td>Number of private IOT devices</td>
<td>27</td>
<td>25,5</td>
<td>2296</td>
</tr>
<tr>
<td>Number of public dashboards</td>
<td>11</td>
<td>6,2</td>
<td>562</td>
</tr>
<tr>
<td>Number of private dashboards</td>
<td>173</td>
<td>135,1</td>
<td>12159</td>
</tr>
<tr>
<td>Number of accesses to dashboards</td>
<td>--</td>
<td>33,9</td>
<td>3048</td>
</tr>
<tr>
<td>Number of minutes</td>
<td>--</td>
<td>337,1</td>
<td>30337</td>
</tr>
</tbody>
</table>
Data-driven design platform for offline advertising

Built on big data to determine the most popular location for a customer group. Automatically select billboards with the highest traction. The platform is capable of predicting the reach of every location on a city based on big data analytics.

Skyrocket the traction of offline campaigns

Citizens will run into more relevant advertisements resulting in higher conversion rates and more successful campaigns.
Snap4City tech. for Industry 4.0

https://www.snap4city.org
Snap4City technology can be exploited on Industry and IOT solutions:

- **Snap4Industry: Snap4City for Industry 4.0** (SLIDES)
- **Scenario: 5G Enabled Water Cleaning Control**
- **Scenario: High Level Control of Industrial Plant**
- **Custom Synoptics and Widgets for Dashboards**
- **The integration between data and devices: the Snap4City solution**
DCS

SCADA

PLC

PLC/RTU

Admin

IoT Broker

IoT Devices/Edge

Industry Plant1......

Fleet management

IoT Broker

IoT Devices/Edge

Industry Plant2......

IoT Broker

IoT Devices/Edge

IoT Broker

IoT Devices/Edge

Internet

SECURE

External Services

Dashboards

IOT Applications

Big Data Analytics, Artificial Intelligence

Control and Supervision on Multiple Supply Chains

Industry 4.0 as a Service
Snap4City Services also on IOT Edge!!!

IOT Networks
- IOT Gateways
- IOT Brokers
- IOT Edge Devices
- IOT Devices

IOT Applications
- Big Data Analytics, Artificial Intelligence
- Mainly fog computing and NGSI V1, V2 with security

Dashboards and Apps

Snap4City (C), October 2020
Snap4City Architecture vs Data Ingestion

Data Sources, External Services
PULL Data

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

Data Ingestion, aggregation, regularization, reconcile:
NIFI, IOT App

Back-End
Knowledge base
Semantic reasoners

Search and Query, Smart City API
Facet, semantic search

Indexing and aggregating
Elastic search

Data Analytics, Simulations
R, Tensor Flow, Python, ...

IOT Applications, Business Logic
Node-RED + Snap4City MicroServices

Front-End
Rendering Acting, Widgets, MicroApps
User interface, Interactive Dashboard, Drill down, maps, heatmaps

Inform, announce, Act!, warning, alarms, What-IF, ..
Security Architecture at a glance

Data Sources
- IoT Devices (sensors, actuators)
- IoT GateWay

Data Injection
- IoT Context Brokers
- IoT Directory

Device Management
- Registries and storage

Cloud Processor
- IoT App

Data Visualization
- Dashboards
- Virtual Devices

Edge Processor
- IoT App
- IoT Edge

Security and Privacy Management
GIDA set up

Smart City data from many sources

ModBus to Snap4City Gateway Edge

5G network devices

IOT Applications

IOT Data Shadow Snap4City

Dashboards and Apps

Big Data Analytics, Artificial Intelligence

Telemonitoring

Telecontrol
Demo UC5 GIDA

GIDA 5G demo

PO_500_a_absorption
Click and drag in the plot area to zoom in

POISON IN EVAPORATION

Fo_300_A_absorption

Temperature

Trend Temperature Prato (°C)

Fo_300_A_absorption

13.6 °C

13.4°C
1020 bar
87 %

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjIyNg==
Green Impact Capacity (GIC)
Altair Control room
Green Impact Capacity (GIC)

- Improve productivity of chemical plant
- Keep GREEN the environmental impact
- Exploiting innovative technologies
- Diversify the production
- Monitoring environmental conditions
Installing Snap4City

https://www.snap4city.org/471
To get an updated version read it!
How to adopt Snap4City

On your premise

Download and deploy

Installation on your premise
- Virtual Machines or Dockers
- Different configurations
  - From small to scalable
  - Exploiting your legacy tools
  - Interoperable with any tool
- No vendor lock-in, No tech lock-in

Mixed solutions! For example:
- Start on Cloud as Smart City as a Service
- Migrate on premise on the fly
- Start on Cloud into a sand box
  - Pass to install on premise what you need

Smart City as a Service
- Supporting Org
- 100% Open Source Platform: Github
- Further developments
- Publishing Appliances and Dockers
- Training courses, docs
- Consulting
- Forums
- Etc.

https://www.snap4city.org
Snap4City Architecture vs Data Ingestion

Data Sources, External Services

PULL Data

- Data Ingestion, aggregation, regularization, reconcile:
  - NIFI, IOT App

Back-End

- Knowledge base
  - Semantic reasoners
- Indexing and aggregating
  - Elastic search
- Data Analytics, Simulations
  - R, Tensor Flow, Python, ….

Front-End

- Rendering Acting, Widgets, MicroApps
  - User interface, Interactive Dashboard, Drill down, maps, heatmaps

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

Snap4City (C), July 2020
Snap4City Architecture

Data Sources, External Services
- PULL Data
- Data Driven, Real Time

Data Ingestion, aggregation, regularization, reconcile
- Tools, [ETL], DISCES, IOT Apps

Big Data Cluster
- HDFS, Hbase, Phoenix
- Semantic reasoners

Knowledge base
- Facet, semantic search

Indexing and aggregating
- Elastic search

Search and Query
- Smart City API

Data Analytics
- R, Tensor Flow, Python, MapReduce, ...

Visual Analytics

IOT Applications
- Node-RED + Snap4City MicroServices

Rendering Acting, Widgets, MicroApps
- User interface, Interactive Dashboard, Drill down, maps, heatmaps

Inform, announce, Act!, warning, alarms, What-IF, ..
Overview of Snap4City platform, for Buyers, for all

Cluster for Smart Processes container: ingestion, analytics, scraping, etc.

Cluster for big data storage: static and real time, Indexing and search

Snap4City MAIN
Dashboard, User Management, etc.

Knowledge base, semantic Store

HeatMaps and Maps

Living Lab Portal

Mobile Apps, Dashboards

Other Services And Servers

IOT brokers

Legacy Platform

IOT Networks
Social Media
CRM
.....
GIS
Overview of Snap4City platform, for Buyers, for all

Snap4City MAIN
Dashboard Builder,
Data Inspector, User Stats,
Res Manager,
ExternalSrv,
MyKPI, MyPOI, Synoptic, IOT Device Manager, Micro Applications, Authorization/Authentiction, Roles, ...

Snap4City MAIN
Dashboard Builder,
Data Inspector, User Stats,
Res Manager,
ExternalSrv,
MyKPI, MyPOI, Synoptic, IOT Device Manager, Micro Applications, Authorization/Authentiction, Roles, ...

[DataCluster]
ETL-VM
Phoenix HBASE, HDFS DISCES, ETL support

KBSSM
KB/ServiceMap, ..
SmartCity API, WFS,
ServiceMap3D, LOG/FLINT, SuperServiceMap, Virtuoso

GISGeoServer
Heatmap Manager,
WFS, WMS

Living Lab Portal
Drupal support CRM, ..

Mobile Apps, Dashboards

Services
CKAN DataGate
Routing Server
Chat Manager
R Studio Server
ETLSDK Server
Engager Server
…… Server

Container Cluster
MCLSCont, NCLSCont
Marathon, Mesos, Zookeeper,
Disces-EM, Executing in Container:
IOT App, Web Scraping, R-Studio,
Python, Java, ETL, ...

IOTOBsFs
IOTOBSFs, secure
IOTBrokers, secure

IOT Networks
Social Media
CRM
.....
GIS

Data Shadow Cluster
IOTDSES
NIFI, Elastic Search, DevDash, Amma

Legacy Platform

[DataCluster]
ETL-VM
Phoenix HBASE, HDFS DISCES, ETL support

GISGeoServer
Heatmap Manager,
WFS, WMS

Living Lab Portal
Drupal support CRM, ..

Mobile Apps, Dashboards

Container Cluster
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IOTOBSFs, secure
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IOT Networks
Social Media
CRM
.....
GIS

Legacy Platform

[DataCluster]
ETL-VM
Phoenix HBASE, HDFS DISCES, ETL support

GISGeoServer
Heatmap Manager,
WFS, WMS

Living Lab Portal
Drupal support CRM, ..

Mobile Apps, Dashboards

Snap4City (C), October 2020
What is included in the Buyers / Full Platform

- **IOTOBSE**
  - IOT Orion Broker
  - Fi-Ware
  - Secure Filter (Snap4City)

- **IOT Edge support**
  - Linux Ubuntu
  - Windows
  - Raspberry Pi
  - Android

- **IOT Devices support**
  - ESP32
  - Arduino

- **IOT Application**
  - Node-RED
  - Snap4City Library of nodes

- **Other Services**
  - Routing Server
  - DataGate CKAN
  - Chat as Rocket
  - ETL SDK VM
  - Engager ..
  - ...

- **Data Analytics**
  - Heatmap production MS Rstudio
  - OD production
  - Predictions MS RStudio
  - Anomaly detection MS RStudio
  - ETL Collection
  - ...

- **MCLSCount, NCLSCount**
  - Container[Cluster]
  - Containers models
  - DISCES-EM
  - Monitoring App

- **ETL Server**
  - Data[Cluster]
  - DISCES
  - Phoenix Drivers
  - Hbase Model
  - ETL processes

- **IOTDSES**
  - DataShadow[Cluster]
  - NIFI process, Squid
  - Elastic Search Model
  - Kibana
  - AMMA data flow
  - DevDash data store

- **KBSSM**
  - Knowledge Base Km4City
  - ServiceMap
  - ServiceMap3D
  - SuperServiceMap
  - LOG/Flint
  - OSM2Km4City
  - Smart City API
  - WFS API

- **GIS GeoServer**
  - GeoServer
  - Heatmap Manager

- **Living Lab Portal**
  - CRM Drupal
  - LDAP Snap4City
  - Registration mng
  - Etc. etc.

- **Snap4City MAIN**
  - Dashboard Builder, Wizard
  - Dashboard Engine
  - Data Inspector, Notificator
  - External Srv manager
  - Menu Manager
  - Ownership Manager
  - Authentication and Authorisation
  - WS server
  - Resource Manager
  - User Stats
  - JavaScript Web App in a Snap
  - MicroApplications
  - Synoptics, custom Widgets
  - IOT device manager: IOT Directory
  - Snap4City MicroServices on IOT Applications: basic and advanced
  - Snap4City GIS Player
  - What-IF tools

---

All in source code, and most of components in Appliances/VMs

Snap4City (C), October 2020
**Platform Maintenance, K3.14**

- **Snap4City modules** are released on GITHUB/DISIT and can be updated from:
  - GITHUB/DISIT into VM Appliance or Servers in which they are installed
    - [https://github.com/disit](https://github.com/disit)
  - Node-RED tool, using official Library regarding: Snap4City Libraries
    - Drupal for the Living-Lab Portal aspects
    - Other tools from their corresponding providers

- **Maintenance** would not be a problem, all users should be capable to perform the updates autonomously

- Updates on new versions will be provided by Snap4City periodically, Notification will be provided on NEWS and GitHUB

Snap4City (C), October 2020
Keeping Platform at the State of The Art

- **Updates** will be provided by Snap4City periodically and released on GITHUB, and other portals.

- **Snap4City team** is involved in contracts since now, so that this will guarantee that the solution will be evolved to anticipate the state of the art as we have done in Iteration 3, in which we released a number of developments.
  - See also the activity of dissemination and updated roadmap
  - See the presence of Snap4City on EOSC, BeeSmartCity, EO15, etc.
  - See the list of concreate developments
  - See the list of supporters on the Stand with respect to those of the 2018
  - See the planned new developments

Snap4City (C), October 2020
Set-up of Open Source version from Scratch

• Guidelines reported on:
  – https://www.snap4city.org/471

• How to proceed:
  – We have presented 7 Configurations models from A: Alone to F: FullPlatform+LivingLab, but they can be customized as you like.
  – By follow the Configurations the Customers are guided to identify the most suitable according to their needs;
  – Once the most suitable Configuration has been identified, they are supported into the:
    i. Download and deploy of the Appliances provided as Virtual Machines or Containers, or
    ii. Download and install modules from GITHUB according to the recipes for VM/Container and the user manual of the single tools, or
    iii. Mixt of the above (i) and (ii) approaches.
  – IOT Edge can created by (1) installing Node-RED, (2) adding Snap4City library of Nodes from the Palette Manager of Node-RED, (3) registering on Snap4City: https://nodered.org/docs/user-guide/editor/palette/manager

Note that some of the material we are presenting has not been published on the portal yet, for the competition.
## Configurations with your business

<table>
<thead>
<tr>
<th>Configuration Kind</th>
<th>Min # VM</th>
<th>Dockers</th>
<th>IOT Broker Int</th>
<th>IOT Broker Ext</th>
<th>MAP</th>
<th>KBSM</th>
<th>IOT APP, MicroServices</th>
<th>Storage &amp; IOT Data Shadow</th>
<th>SSO, Roles</th>
<th>IOT Security</th>
<th>Dash + Wizard</th>
<th>GIS in</th>
<th>GIS out</th>
<th>Heatmap</th>
<th>Mob. App</th>
<th>ASCAPI</th>
<th>Living Lab Sup.</th>
<th>Options supported by the configuration</th>
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</thead>
<tbody>
<tr>
<td>A: Alone</td>
<td>1</td>
<td>6</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1 mf</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>(x)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ETL, DG, CM</td>
<td></td>
</tr>
<tr>
<td>B: Basic</td>
<td>2</td>
<td>7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1 mf</td>
<td>Small</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, CM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C: CityStart</td>
<td>3-4</td>
<td>8-9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1 mf</td>
<td>Small</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, R, CM, Eng</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D: DataCity</td>
<td>5-6</td>
<td>Ask</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>70</td>
<td>Mediu m</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, R, CM, Eng, LL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E: ExtensiveCity</td>
<td>6-8+</td>
<td>Ask</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>70</td>
<td>Scalable</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, R, CM, Eng, LL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F: FullPlatform</td>
<td>12-14+</td>
<td>Ask</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Scalable</td>
<td>Scalable</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, R, RS, CM, Eng, LL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F: FullPlatform + LivingLab</td>
<td>13-15+</td>
<td>Ask</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Scalable</td>
<td>Scalable</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ETL, DG, R, RS, CM, Eng</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

mf: multiple flows for each IOT App
Read next slide for the other notes and legend

Snap4City (C), October 2020
Legenda and Notes on the previous table

• In all configurations you:
  – have: Multiple IOT Brokers; unlimited number of data sources; interoperability support; KB
  – may have: HA, DRS, FT, Balancing, cloning and configuring additional VM;
  – may pass at the next configuration without reinstalling the VM;
  – may add one or more Optional Services as VM/Containers: ETL, DataGate, Routing, Engager, Data Analytics, etc. etc.

• From Config. E:ExtensiveCity and upper the number of VMs depends on the volume of DataStorage and the volume of Data Stream in input.
  – These two aspects are managed by two independent clusters of VMs and scale independently each other. This allows to satisfy any different combination of volumes in streams and data storage.

• We suggest using Living Lab support only on FullPlatform, while it can be installed on Smaller Configurations with some limitations in terms of features

Optional Services
• DG: DataGate CKAN
• R: Routing
• ETL: ETL SDK VM
• RS: R Studio Server
• Eng: Engager
• CM: Chat Manager
• LL: Living Lab
• ..
• ..
Computational and Storage Costs

• **The VM** is considered (appliances are provided) as 16/24 cores 2.2 Ghz, 16-24 GB Ram, 500 GB HD in thin provisioning, with 25-40 GB HD used at the start, in most cases Debian.
  – to estimate the needed CPU, RAM, Storage for each configuration it is easy from the #of VM in the configuration.
  – Please note that configurations A and B can be executed on 4 cores, 4 GB Ram, ..

• **In solutions**, with a very large number of users on the Front End: Smart City API (mobile App users, Dashboard users, a frontend balancer and more FrontEnd servers would be needed). Please note that the Smart City API are also used by DataAnalytics processes and by MicroServices in the IOT Applications.
  – Typically a thousand of simultaneous users on the front end can be sustained for each VM
  – More precise estimations can be performed by knowing the actual workload
A) Alone Configuration
A: Alone) For Small Size Business, for example an industry 4.0 application you can need to install only one VM: Snap4CityMAINVM

• Snap4City MAIN VM
  – Dashboard Builder, Wizard
  – Dashboard Engine
  – Data Inspector, Notificator
  – External Srv manager
  – Menu Manager
  – Ownership Manager
  – Authentication and Authorisation
  – WS secure server
  – Resource Manager
  – User Stats
  – JavaScript Web App in a Snap, MicroApplications
  – Synoptics, custom Widgets
  – IOT device manager: IOT Directory
  – Snap4City MicroServices on IOT Applications: basic and advanced
  – Snap4City WFS player
  – What-IF tools

• For connecting data sources to Dashboards onpremise!
  – Data driven solution, no large data store
  – Industry 4.0
  – Small Smart City business
  – Start with Snap4City platform as seeding element
  – Storage: ODBC, JDBC, Mongo, SPARQL, MySQL, etc.
Snap4CityMAIN: Alone Configuration

• As Virtual Machine:
  – HOW TO: configure/install StartSNAP4CITYVM: starting appliance of Snap4City
  – https://www.snap4city.org/487

• As Container Composer:
  – HOW TO: configure/install StartSNAP4CITYVM: starting appliance of Snap4City
  – https://github.com/disit/snap4city-docker/tree/master/Alone
B) Basic Configuration
B: Basic) Addressing a relevant number of IOT devices/ IOT brokers in your smart city or industry 4.0, a few smart Applications with multiple flows

For managing beyond A: Alone Configuration

+ large number of IOT devices and brokers, any protocol, format
+ IOT Devices
+ IOT Edge
+ Etc.
Addressing a relevant number of IOT devices/ IOT brokers, a few smart Applications

- **IOT Edge**: local intelligence, processes and Applications located on the field, on premise. Those autonomous smart tools can be implemented by IOT Applications working on IOT Edge:
  - Linux Ubuntu Appliance VM: https://www.snap4city.org/drupal/node/298
  - Android as IOT Edge https://www.snap4city.org/drupal/node/278
  - Raspberry Pi as IOT Edge: https://www.snap4city.org/drupal/node/77

- **IOT Applications** = Node-RED + Snap4City libs of Nodes/MicroServices,
  - Available in Snap4CityMAIN VM, so that in any installation
  - any installation of Node-RED add Snap4City Library from the official Library of Node-RED, add new Nodes into the Palette as
    - https://nodered.org/docs/user-guide/editor/palette/manager
  - Snap4City MicroService collection from the JS foundation with full documentation inside https://flows.nodered.org/?term=snap4city
    - **BASIC**: suitable for Final User
    - **ADVANCED**: DEVELOPER (you have to install both libraries: basic and advanced)
C) CityStart Configuration
C: CityStart) Addressing a relevant number of GeoLocated Points of Interest, PIN on maps, and eventually heatmaps, a Small Smart City with a few smart IOT applications on cloud and many on edge

For managing Beyond B: Basic Configuration

+ Large number of GEO elements on maps
+ Heatmaps
+ Geo shapes
+ GIS, ....
C: CityStart) Addressing a relevant number of GeoLocated Points, heatmaps, ...

- **KMSSM VM:**
  - Knowledge base, KB, positioning elements on maps, enabling geo-spatial and temporal reasoning
  - Ingestion OSM to load on KB, ServiceMap and reasoning on it
  - GeoReverse data, from street to data and vice versa
  - WFS export and import

- **GIS GeoServer VM:**
  - Producing and providing heatmaps
  - Managing Heatmaps colour maps.
  - WMS, WFS export, distribution
D) DataCity Configuration
D: DataCity) A medium/large size Smart City with a number of smart applications on cloud and a number of IOT brokers, relevant volume of data entering into the cloud.
D: DataCity) A medium/large size Smart City with a number of smart applications on cloud and a number of IOT brokers, relevant volume of data entering into the cloud.

For Managing

**Beyond C:CityStart Configuration**

+ A relevant number of IOT Applications for data transformation and Analytics
+ A small sized Data Shadow for IOT data management

**Optionally:**

- Data Analytics in R Studio, Tensor Flow (NVIDIA)
- Hbase / Phoenix Big Data Store
- Data Gate CKAN for Open Data
- Chat Manager on Dashboard
- Routing Solutions
Ds) DataCity-small Configuration
Smart City Functional Architecture, V2

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

IOT Applications, Business Logic
Node-RED + Snap4City MicroServices

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

Back-End
Data Ingestion, aggregation, regularization, reconcile:
NIFI, IOT App

Knowledge base
Semantic reasoners

Indexing and aggregating
Elastic search

Search and Query, Smart City API
Facet, semantic search

Front-End
Rendering
Acting, Widgets, MicroApps
User interface, Interactive Dashboard, Drill down, maps, heatmaps

Snap4City (C), October 2020
D: DataCity-Small) A small size Smart City with a 4 smart applications on cloud and 2 of IOT brokers, limited volume of data entering into the cloud.
For Managing

**Beyond C:CityStart Configuration**

- A limited number of IOT Applications for data transformation and Analytics
- A small sized Data Shadow for IOT data management

Optionally:

- Data Gate CKAN for Open Data
E) ExtensiveCity Configuration
E: ExtensiveCity) A Large size Smart City with smart applications on cloud and a number of IOT brokers, large volume of data streams entering in the cloud.

Snap4City MAIN
- Dashboard Builder
- Widgets
- IOT App1
- Notificator
- WS Server
- Data Inspector
- User Stats
- ExternalSrv
- Resource Manager
- MicroApps
- Authorization/Authentic.
- MyKPI
- MyPOI
- Synoptic

IOT Device Manager

Services
- CKAN DataGate
- Routing Server
- Chat Manager
- R Studio Server
- ETLSDK Server
- Engager Server
- ....... Server

MCLSCont
- Mesos Balancing
- Crt. Scheduling
- DISCES-EM: Cloud Elastic Management

SmartCityAPI KB/ServiceMap
- GIS, GeoServer
- LOG/FLINT
- Virtuoso

GIS, GeoServer

IOT Context Broker
- ProxyFilter Security

IOT Broker

IOTDSES
- kibana
- elasticsearch

GIS, GeoServer

……. Server

Developer Balancer

SCAPI Balanc.
E: ExtensiveCity) A Large size Smart City with smart applications on cloud and a number of IOT brokers, large volume of data streams entering in the cloud

For Managing

**Beyond D:DataCity Configuration**

- A relevant number of data streams entering in the platform
- A scalable Data Shadow for IOT data management

Optionally:

- Data Analytics in R Studio, Tensor Flow (NVIDIA)
- Hbase / Phoenix Big Data Store
- Data Gate CKAN for Open Data
- Chat Manager on Dashboard
- Routing Solutions
F) FullPlatform Configuration
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

For Huge scale Smart City with a Huge number of smart applications and processes on cloud (thousands), any number of IOT brokers

Snap4City MAIN
Dashboard Builder
Wizard, Widgets, IOT App1
Notificator, WS Server,
Data Inspector, User Stats,
ExternalSrv, Resource Manager, MicroApps
Authorization/Authentic.
MyKPI, MyPOI, Synoptic
IOT Device Manager

SmartCityAPI
KB/ServiceMap
ServiceMap3D
LOG/FLINT
Virtuoso

VM on Cloud HA, DRS, [FT]
**F: FullPlatform)** For Huge scale Smart City with a Huge number of smart applications and processes on cloud (thousands), any number of IOT brokers

- MCLSCount
- NCLSCount
- Container[Cluster]
  - Marathon, Mesos Cluster
  - Containers models
    - IOT App
    - Web Scraping
    - Data Analytics
    - ETL
    - Python
    - ...
  - DISCES-EM
    - Elastic management of containers
  - Monitoring App

**For Managing**

*Beyond E: ExtendedCity Configuration*

+ A scalable huge number of Containers including different kind of processes: IOT, ETL, data analytics, scraping
+ A scalable Data Shadow for IOT data management

**Optionally:**

- Data Analytics in R Studio, Tensor Flow (NVIDIA)
- Hbase / Phoenix Big Data Store
- Data Gate CKAN for Open Data
- Chat Manager on Dashboard
- Routing Solutions
F+) LivingLab Configuration
F-LivingLab: FullPlatform + LivingLab) For Huge scale Smart City as Full Platform plus Living lab Support

Services
- CKAN DataGate
- Routing Server
- Chat Manager
- R Studio Server
- ETLS SDK Server
- Engager Server

Container Cluster
- MCLSCont, NCLSCont
- Marathon, Mesos, Zookeeper,
- Disces-EM, Executing in Container:
- IOT App, Web Scraping, R-Studio,
- Python, Java, ETL, ...

Snap4City MAIN
- Dashboard Builder,
- Data Inspector, User Stats,
- ExternalSrv, Res Manager,
- MyKPI, MyPOI, Synoptic, IOT
- Device Manager, Micro
- Applications, Authorization/
- Authentication, Roles

[DataCluster]
- ETL-VM
- Phoenix HBASE, HDFS
- DISCES, ETL support

KBSSM
- KB/ServiceMap,
- SmartCity API, WFS,
- ServiceMap3D, LOG/FLINT,
- SuperServiceMap, Virtuoso

IOTOBFSs
- IOTBrokers, secure

Data Shadow Cluster
- IOTDSES
- NIFI, Elastic Search, DevDash, Amma

GIS GeoServer
- Heatmap Manager,
- WFS, WMS

IOT Networks
Social Media
CRM
GIS

Living Lab Portal
- Drupal support CRM

Legacy Platforms

Mobile Apps, Dashboards

Snap4City (C), October 2020
F-LivingLab: FullPlatform + LivingLab) For Huge scale Smart City as Full Platform plus Living lab Support

Living Lab Portal
- CRM Drupal
- LDAP Snap4City
- Blogs, Articles, comments, etc.
- Multiple Organization
- Multiple Groups
- SSO with Snap4City tools
- Automated Registration management
- SOLR indexing on content
- Monitoring activity
- Reporting and statistics

For Managing

Beyond F: FullPlatform Configuration
+ Providing Living Lab Support, a full CRM for stakeholder, co-working, collaborative work, discussion environment, chart, forum, etc.

Strongly suggested:
- Data Analytics in R Studio, Tensor Flow (NVIDIA)
- Hbase / Phoenix Big Data Store
- Data Gate CKAN for Open Data
- Chat Manager on Dashboard
- ETL SDK servers
- User Engagement Server
- Routing Solutions
THE VIEW OF THE ADMINISTRATOR
Snap4City Architecture

Data Sources, External Services
- PULL Data

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

Data Ingestion, aggregation, regularization, reconcile
- NIFI
- Tools, [ETL], DISCES, IOT Apps

Big Data Cluster
- HDFS, Hbase, Phoenix

Knowledge base
- Semantic reasoners

Indexing and aggregating
- Elastic search

Search and Query
- Smart City API
  - Facet, semantic search

Data Analytics
- R, Tensor Flow, Python, MapReduce, ...

Visual Analytics

IOT Applications
- Node-RED + Snap4City MicroServices

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

Rendering Acting, Widgets, MicroApps
- User interface, Interactive Dashboard, Drill down, maps, heatmaps

Snap4City Architecture
Management by Organization

- **Organizations** may have
  - name, ID, GPS center, a number of Groups on Snap4City.org
  - users of different kinds and may impose early bounds on the resourced used by users (IOT Dev, IOT App, Dash)
  - on cloud users kinds up to level of Tool Administrator

- **ToolAdmin** users (requested by Organizations) may
  - control processes, consumption of resources, healthiness, etc.
  - manage tools exploited in your configuration

- **24H/7D Help Desk and Assistance**
• https://www.snap4city.org/drupal/contact

• Bug Reporting
  – https://docs.google.com/forms/d/e/1FAIpQLSfDQtKqgLllyycNXiazeYEH1SsRG1YL8Ze4ThD8nZoA5jsoXw/viewform

• For Service Level Agreement see:
  – Service Level Agreement

• Help Desk and Contact:
  – https://www.snap4city.org/3

• Availability rates:
  – https://www.snap4city.org/388
Monitoring Resource Consumption and Traffic
Monitoring Infrastructure Status

http://www.disit.org/dashboardSmartCity/view/index.php?iddasboard=MTQ4


Computational Capabilities of Snap4City

- **Managing:**
  - Periodic Processes $\rightarrow$ ETL, IOT App (Node-RED)
  - Asynchronous processes, data driven, real time $\rightarrow$ Node-RED, IOT Applications

- **Scalability**
  - Horizontal: Increasing processes performing activities, demand on new processes for new users, for new applications, for new IOT applications: VM, Hosts, clusters, Storage SAN
  - Vertical: Increasing resources on processes: CPU, MEM, Storage, Network
DevDash Case Study (2)

- Detect potential anomalies or disfunctions by inspecting the DevDash tool time trend
Managing and Monitoring Data-Traffic in the BackOffice
AMMA (1)

Monitor data traffic flows among IoT devices, services, applications etc. and detect potential anomalies

Unexpected behaviors can be revealed by inspecting the data flow time trend:

a) detecting peaks or valleys in the trend

b) drill-down on data to identify single/more malfunctioning devices and/or services

quantitatively monitoring data/message traffic and flows
AMMA (2)

Make drill-down activities on data related to a single Process ID and check for unexpected behavior in the Time Trend panel:

**c)** Filtering data by the Process ID (e.g. for example those related to a SmartWaste container)

**d)** Detect a peak with more data traffic than expected during its scheduled activity, by properly filtering on time, the single data portion corresponding to the unexpected data flow can be viewed

**e)** Locate on map the single involved device or service
AMMA by Elastic Search + Kibana
DevDash by Elastic Search + Kibana
Operator Business Analysis
Dashboards: DevDash, AMMA

- Dynamic Filtering, Adaptable, ...
- Full data details, drill down,...
- Synergic with Data Inspector which addresses data relationships, processing and information
Auditing Activities
Managing Back Office Processes via Containers
Hosts with VM on Cloud HA, DRS, FT

Masters in HA: Marathon/Mesos, Zookeeper, ....

Pool of Containers
- NodeRed, Java
- Pentaho Kettle, Java, Karma
- R-Stat, R-Parallel
- Hadoop/Spark/SparkML
- Python, C++, C, Java

Containers Control API

Monitoring API

VM Control API

DISCES + Planner + Elastic Management

Resource Monitoring & Cloud Resource Management

Cloud Elastic Management

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Elastic Scaling: allocating / deallocating

• Allocation/ deallocation, Rebalancing vs compacting
  – Vertical of resources: Docker and/or VM: CPU, Mem
    • NodeJS multi-flow for each Docker, the user request data flows and IOT App, Snap4City allocates them dynamically on demand and perform workload optimization
    • VM: management of Mem, CPU; transparent and automatic in DRS VMware
  – Horizontal of resources of Dockers and/or VM and/or [Host]:
    • Docker: addition of containers, migrations/moving, balancing (per moving) of IOT App
    • VM: on/off

• Monitoring resources:
  – VM via VMware API, Docker via Marathon and Mesos APIs

• Algorithm in Python for scaling, actions via APIs: VMware, Marathon,..
Monitoring on Cloud
DISCES: Distributed SCE Scheduler

**Smart Cloud Engine**

<table>
<thead>
<tr>
<th>Schedulers Name</th>
<th>ID</th>
<th>FIRE Instance ID</th>
<th>DATE</th>
<th>JOB NAME</th>
<th>JOB GROUP</th>
<th>JOB DATA</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISCES</td>
<td>6</td>
<td>07/05/2020</td>
<td>1250</td>
<td>running01</td>
<td>running01</td>
<td>running01</td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>07/05/2020</td>
<td>1250</td>
<td>running02</td>
<td>running02</td>
<td>running02</td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>07/05/2020</td>
<td>1250</td>
<td>running03</td>
<td>running03</td>
<td>running03</td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>07/05/2020</td>
<td>1250</td>
<td>running04</td>
<td>running04</td>
<td>running04</td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>07/05/2020</td>
<td>1250</td>
<td>running05</td>
<td>running05</td>
<td>running05</td>
<td>Running</td>
</tr>
</tbody>
</table>

**CPU Usage**
- Total CPU usage: 12.08%
- Total scheduler: 1.08
- Running: 0.76
- Total: 1.08
- Unallocated: 0.76
- Total: 0.76
- Free: 0.76

**Memory Usage**
- Total memory usage: 5.63 GB
- Total scheduler: 0.63 GB
- Running: 0.41 GB
- Total: 0.41 GB
- Unallocated: 0.41 GB
- Total: 0.41 GB
- Free: 0.41 GB

**System Load**
- CPU load: 0.12
- Memory load: 0.08

**Other Statistics**
- Jobs Failed/Success: 221 (4.45%) / 2879 (84.1%)
- Jobs Failed/Success (24 h): 4742 (95.55%)
- Jobs Failed/Success (7 days): 3156 (91.55%)
Acknowledgements
Main running projects

- 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
- 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, Living Lab
- Lonato del Garda → smart parking, environment
- Herit Data → tourism, culture and management
- ISPRA JRC → site management and services

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Acknowledgements

• Thanks to the European Commission for founding. All slides reporting logo of Snap4City https://www.snap4city.org of Select4Cities H2020 are representing tools and research founded by European Commission for the Select4Cities project. Select4Cities has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation Programme (grant agreement n° 688196).

• TRAFAIR is a CEF project. All slides reporting logo of TRAFAIR project are representing tools and research founded by the EC on CEF programme http://trafair.eu/.

• Thanks to the European Commission for founding. All slides reporting logo of REPLICATE H2020 are representing tools and research founded by European Commission for the REPLICATE project. REPLICATE has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation Programme (grant agreement n° 691735).

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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.
DISIT thanks to

Herit Data: Tourism and Mng.  [https://herit-data.interreg-med.eu/](https://herit-data.interreg-med.eu/)
Snap4City: IOT/IOE smart city  [www.snap4city.org](http://www.snap4city.org)
Trafair: CEF project with several Cities  [http://trafair.eu/](http://trafair.eu/)
Mosaic: Mobility and transport model  
Km4City:  [http://www.km4city.org](http://www.km4city.org)
REPLICATE H2020, SCC1, EC flagship  
[http://replicate-project.eu/](http://replicate-project.eu/)
Sii-Mobility SCN MIUR:  [http://www.sii-mobility.org](http://www.sii-mobility.org)
Feedback: retail and GDO Big Data analytics  
5G with 3G-Wind, Open Fiber, Estra  
Coll@bora Social Innovation, MIUR:  
[http://www.disit.org/5479](http://www.disit.org/5479)
RESOLUTE H2020, EC:  
[http://www.resolute-eu.org](http://www.resolute-eu.org)
TRACE-IT, RAISSS, TESYSRAIL, ...
Mobile Emergency:  
[http://www.disit.org/5404](http://www.disit.org/5404)
Further readings

- HOW TO: create a Dashboard in Snap4City
- HOW TO: add a device to the Snap4City Platform
- HOW TO: add data sources to the Snap4City Platform
- HOW TO: define privacy rules for personal data, produced by the end-users own device
- HOW TO: Develop Smart Applications, Snap4City development Life Cycle
- HOW TO: HLT vs Ingestion, and HLT vs Widgets
- HOW TO: Develop an IOT Application for Data Ingestion
- HOW TO: Upload data into Knowledge Base, ServiceMap (triple upload)
- HOW TO: Create as set of Devices with BulkProcessing
- HOW TO: Create an IOT Device Model
- HOW TO: Create an IOT Device Instance from IOT Directory tool
Be smart in a SNAP!

www.snap4city.org

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