URBANITE

Supporting the decision-making in urban transformation with the use of disruptive technologies

Deliverable D3.5

Data curation module Implementation v1

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Abstract:	This deliverable will have two versions and will present the software implementation of the data curation module accompanied with the design specification and documentation. This deliverable is the result of Task 3.2.
Keyword List:	Curation, Preparation, Transformation, Data Management, Data Quality, Software
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Document Description

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v0.1	16/07/2021	Draft ToC	FhG
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v0.3	17/09/2021	Requirements and inclusion of subchapters in technical description	TECNALIA
v1.0	05/10/2021	Suggestions by reviewers	FhG

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Terms and abbreviations

API	Application Programming Interface
EC	European Commission
CC	Creative Commons
CSV	Comma Separated Values
DCAT	Data Catalogue Vocabulary
DCAT-AP	DCAT Application Profile
GPS	Global Positioning System
HTML	HyperText Markup Language
HTTP	HyperText Transport Protocol
HTTPS	Hypertext Transfer Protocol Secure
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
JSON-LD	JavaScript Object Notation Linked Data
MIF/MID	MapInfo Interchange Format
NGSI	Next Generation Service Interface
NGSI-LD	Next Generation Service Interface Linked Data
REST	Representational State Transfer
RDW	Specific Open Data Portal of Amsterdam
SOAP	Simple Object Access Protocol
SPDP	Standard for Publishing Dynamic Parking Data
URL	Uniform Resource Locator
XML	eXtensible Markup Language
XSD	XML Schema Definition

Executive Summary

This deliverable contains an overview over the software components that are related to the tasks of data manipulation between initial harvesting and storage. This includes, but is not limited to, the steps of data anonymization, preparation, transformation, and curation. Depending on the nature and quality of the harvested data none, some, or all of these steps could be necessary. The common goal regardless of the data's origin is the conversion into the applicable domain specific FIWARE Smart Data Model. These are described in deliverable D3.4 [1]. Only those components that were needed in achieving this for the data sources connected have been developed thus far. More precisely, especially the curation and anonymization modules, along with more transformers, will be shipped with the v2 release of this set of components. For each existing component an overview along with a description is given. Where applicable, details on configuration and usage are provided.

The components that are responsible for the aforementioned tasks integrate into the Piveau Pipeline Concept. Hence, this deliverable frequently references to deliverable D3.2 [2] when touching the theoretical background of this architectural concept. There, the Piveau Pipe is described thoroughly.

1 Introduction

The term Data Management Platform stands for a variety of distinct software components that work together to deliver the key functionalities that are data harvesting, data anonymization/preparation/transformation/curation, and data aggregation and storage. The three deliverables D3.2, D3.5, and D3.7 focus on these core features respectively. Due to the interaction between these modules, the aforementioned deliverables should be understood as a collection of documents related to the same overarching concept that is the Data Management Platform.

In this deliverable a distinction is made among the terms “anonymization”, “preparation”, “transformation” and “curation”. Anonymization aims to address privacy protection removing personally identifiable information from data sets, so that the people whom the data describe remain anonymous (this is compliant with GDPR regulations). Preparation refers to the process of ensuring a certain level of (meta-)data quality. [3] This includes detecting and removing false/implausible data for example. Validating against a given specific schema could be one way of achieving this. Transformation is the conversion from one format into another, without altering the (meta-)data’s semantics. Data curation is considered the maintenance and enrichment of data after the previous steps have been completed. [4]

1.1 About this deliverable

Within the Data Management Platform this deliverable focuses on the data anonymization, preparation, transformation, and curation. It presents the challenges involved in these steps, the proposed solution, and their implementation.

1.2 Document structure

Section 2.1 covers the functionalities provided by the anonymization, preparation, transformation, and curation components as well as how they fit into the general URBANITE architecture. This is followed by an overview of the available components and their technical functional descriptions in section 2.2. This includes the technical details that diverge from the ones discussed in deliverable D3.2. Next, section 3 contains instructions on how to build, configure, and run the application(s). The document wraps up with a conclusion and references.

2 Implementation

2.1 Functional description

The different kinds of data and metadata that have been harvested by the various importers or connectors (covered in D3.2) need to be sometimes anonymized (if they contain personal and/or sensitive information), and prepared/transformed/curated for further processing. After the data and metadata has been checked for quality/consistency they are brought into a common format. The common format used in URBANITE is described in D3.4 [1]. Finally, they are stored in dedicated databases, which is covered in deliverable D3.7 [5].

The functional requirements for these components were listed in deliverable D5.1 [6] and a detailed design was provided in deliverable D5.4 [7]. We present here a short summary and the status of development. All the requirements applicable to the data models and datasets that are covered in the first prototype, have been fulfilled or partially fulfilled. More data models will be supported for the second version.

Component	Requirements in D5.1	Current Status
Data Preparation	DC.07 Data license support. The module must check the data licenses and provide understandable information to the owners and the user of the data. For combined data sets with different licenses, it detects possible compatibility issues and informs users how to use and share the data	Partially fulfilled: The module checks the license and adds this information in the metadata. However, licenses of combined datasets are still not managed automatically
	DC.05 Data validation and quality check. The data curation module must be able to validate the data provided by data harvesting module and its quality based on a defined format.	Partially fulfilled: Not all quality checks have been implemented in v1
Data transformation	DC.01 Data transformation after harvest. The harvested data may not be in a format and/or structure suitable for data storage. In this case, the data will need to be transformed in an automated way.	Fulfilled
	DC.03 Data Annotation. Data transformation module should add annotation in the form of metadata to data to help the analysis. This metadata will be included in the data itself.	Fulfilled
	DC.06 Data Interoperability. Data transformation module should provide functionalities clean and annotate data to common semantics and data models, thus guaranteeing interoperability. It is important to note that there will not be one single common format that all data will be transformed into. Instead, established formats within the various domains will be targeted for transformation.	Fulfilled

	DC.08 Pipeline between data harvesting and curation modules. The data curation module must provide an API (REST service or MQTT endpoint) so that the data harvesting module can forward the data that has been retrieved.	Fulfilled
Data Curation	DC.02 Data Cleaning. Data curation module should be able to clean the data coming from the harvester eliminating duplicates or error.	Fulfilled
Data anonymization	DC.04 Data anonymization. This module shall anonymize or pseudonymize data. Data anonymization could be done at the source or before storing it, depending on the use case. In any case, URBANITE platform will provide the anonymization functionality for users (UCs) to use it before the data is uploaded/used by the URBANITE platform.	Partially fulfilled. Solution is available, but not yet integrated.

2.1.1 Fitting into overall URBANITE Architecture

Like the harvesting modules the components involved in data anonymization preparation, transformation, and curation are also part of the backend services of the URBANITE architecture. As such, the standalone modules follow a microservice approach making them a good fit with the Docker-based architecture designed in WP5. They also scale well, which is a key requirement when frequently processing potentially large amounts of data. The components that are described in this deliverable are highlighted in green in Figure 1, which comes from deliverable D5.4.

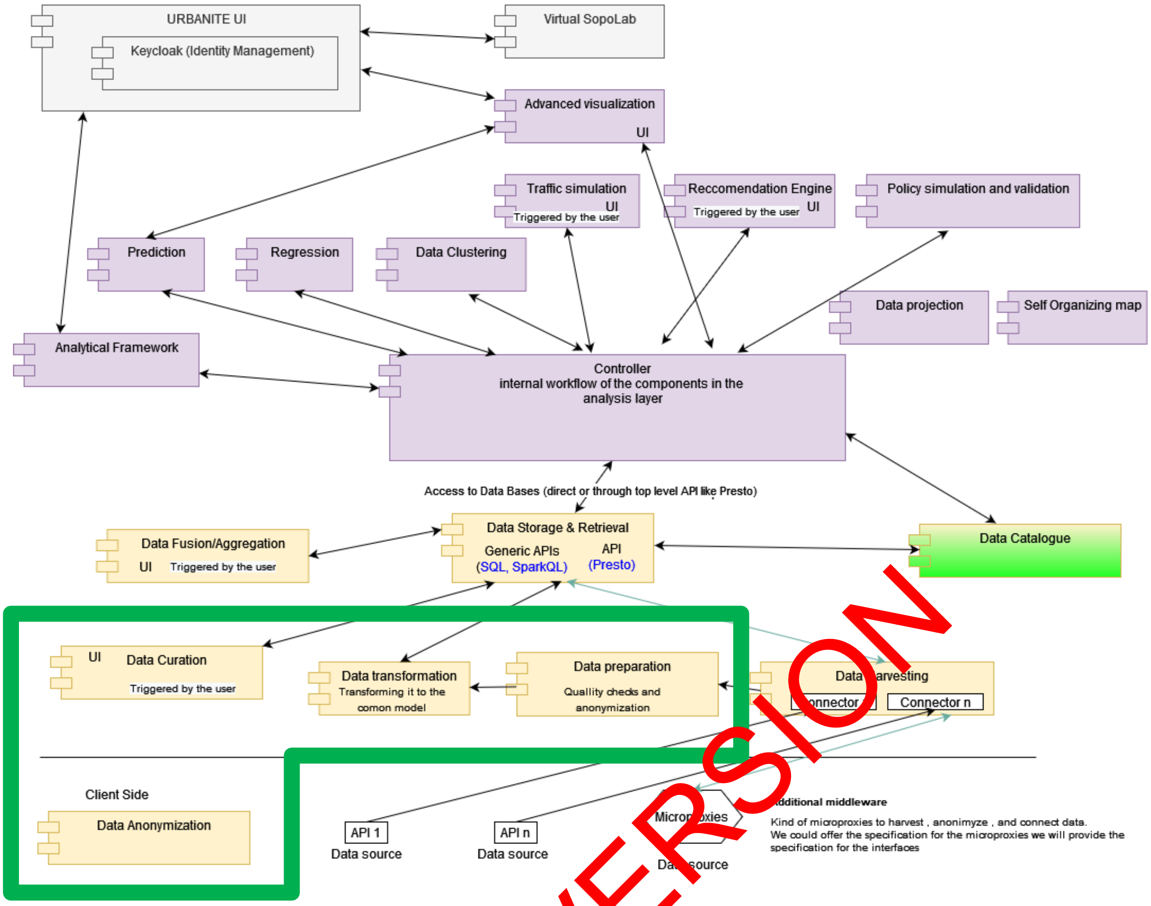

Figure 1: URBANITE architecture

2.2 Technical description

2.2.1 Data Preparation

Data Preparation refers to the process of ensuring a certain level of (meta-)data quality. According to ISO/TS 8000-1:2011[1], data quality is the "degree to which the characteristics of data satisfy stated and implied needs when used under specified conditions". Hence, data quality is not an independent concept. It can only be assessed meaningfully by considering the intended usage of the data and the context, in which the data is applied. For this reason, collaborative work between WP3, WP4 and WP6 has been carried out to identify the use case and information needs.

Before data is used by the algorithms and simulation models, we need to ensure that it meets certain quality criteria. Some of these quality checks are done in the data preparation or transformation steps while others can be done over already stored data. The ISO Standard 25012:2008[2], defines fifteen quality aspects: Accuracy, Completeness, Consistency, Credibility, Correctness, Accessibility, Compliance, Confidentiality, Efficiency, Precision, Traceability, Understandability, Availability, Portability, and Recoverability. Next, we describe the quality aspects analysed in URBANITE:

[1] ISO (2011). ISO /TS 8000-1:2011 Data Quality – Part1: Overview.
[2] https://www.iso.org/standard/35736.html

- **Accuracy**. It refers to error-free records that can be used as a reliable source of information. For example, we need to check whether the measurement is between its minimum and maximum possible values (e.g.: traffic intensity cannot be negative, an ambient temperature observation in a city is usually lower the 45 degrees, etc), or pattern checks for strings or dates, as well as values being inside a set for days of the week, among others.

  As an example, in the data quality checks of the harvested data related to traffic flows, it was detected that occasionally some sensors sent negative intensities, which is not possible. Hence, all negative values are discarded and considered as errors (Figure 2).

```
if (!entry.properties.Intensidad
   || entry.properties.Intensidad < 0) {
            continue;
}
```

Figure 2: Skipping empty/invalid readings in traffic flow

- **Completeness**. In this case we need to check the number of available records in a specific range of time. For example, for traffic analysis, traffic flow data is aggregated in 5 and 15-minute periods. However, we cannot count on the fact that the sensors will always provide data every 5 minutes. So, we need to check the number of "holes" within the data to evaluate its quality. In addition, we also check the metadata completeness, i.e. that the main metadata attributes are available and if not, we complete them (if possible).
- **Consistency**. When aggregating data from multiple sources, we need to check if there is consistency in measurement of variables throughout the datasets.
- **Precision.** Precision is the depth of knowledge encoded by the data, e.g. resolution of images, the degree of dis-aggregation of statistics or the number of decimals for numerical data.

2.2.2 Data Transformation

Data transformation is a key step in the Piveau Pipeline Concept. It cannot be expected that the municipalities provide their data in one of the common data models developed by FIWARE used in the URBANITE context. As such, the transformation of the heterogeneous data sources into common models is vital for frictionless processing of the data henceforth. All architectural requirements and design constraints described in the respective section in D3.2 [2] also apply to the modules covered in this deliverable. Please refer to D3.2 for details on this topic. At time of writing a number of generic transformation related components have been developed. These are geared towards reusability and/or customizability. The aim here is that they can be employed for a wide variety of data formats, in order to keep the required effort of writing dedicated software for each new data source to a minimum. The following components have been developed:

- JSON to JSON
- CSV to JSON
- XLS(X) to JSON

These are covered in the next sections.

2.2.2.1 JSON to JSON

This transformer converts a given JSON structure into another JSON structure by means of JavaScript instructions.

In URBANITE, the harvested data is transformed into NGSI-LD format according to the data models defined in D3.4. For each data source, a different JavaScript file needs to be developed. It is also the responsibility of the transformer to adapt the data to the needs imposed by the NGSI-LD model, for example date formats, value ranges, etc ...

The JavaScript file must cohere to some standards to ensure flawless evaluation. More precisely, it must feature a function named `transforming`, which takes a JSON object or array as its sole parameter. The function must return a JSON structure that is compliant with the URBANITE common data models based on FIWARE Smart Models. An example of what this can look like when transforming weather data is shown in Figure 3. The input would have to be a JSON object containing two fields, `data` and `metadata`. The former is transformed, the latter passed along as-is.

```
function transforming(input) {

  var output = {
    "@context": [
      "https://smartdatamodels.org/context.jsonld",
      "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld"
    ],
  };

  output.type = "WeatherObserved";
  output.source = "https://openweathermap.org/";
  output.temperature = input.data.main.temp;
  output.atmosphericPressure = input.data.main.pressure;
  output.windSpeed = input.data.wind.speed;
  output.windDirection = input.data.wind.deg;

  return {
    "metadata": input.metadata,
    "data": output
  };
}
```

Figure 3: Example of a JSON Transformation Script

In some cases, transformations need to be done not only to the format but also to the values. For example, percentage values from 0 to 100 may need to be adapted to ranges between 0 and 1; date formats may need to be transformed from string values to Epoch integers. In the case of Bilbao's air quality data, the date is harvested in the format `dd/mm/yyyy hh:mm` whereas the NGSI-LD format requires it as `yyyy-MM-dd'T'HH:mm:ss`. This means that a transformation as shown in Figure 4 is required.

```
var datetime = lastMeasureDate.split(" ");
var datepart = datetime[0].split("/");
var timepart = datetime[1].split(":");
output.dateObserved = datepart[2] + "-" + datepart[1] + "-" +
datepart[0] + "T" + timepart[0] + ":" + timepart[1] + ":00";
```

Figure 4: Example of a datetime transfomation

A complete example of a transformation script for air quality data from the Bilbao use case, including the JSON structure that is the output of the data harvester, the JavaScript file used for transformation, and the output of the transformer, that is a JSON in NGSI-LD format compliant to `airQualityObserved` FIWARE data model, is provided in the annex.

2.2.2.2 CSV to JSON

This transformer converts CSV into a JSON structure for further processing. Each row is mapped to a JSON array containing the field's values. An example of what this can look like is shown in Figure 5.

```
[
  ["ID", "Name", "Age"],
  ["1", "Jane", "25"],
  ["2", "John", "26"],
  ...
]
```

Figure 5: Example of CSV to JSON transformer

2.2.2.3 XSL(X) to JSON

This transformer converts XLS or XLSX files into a JSON structure for further processing. The data type must be configured in the applicable segment in the pipe descriptor. It can also be toggled whether to skip empty rows.

```
{
  "sheet_1": [
    [ "ID", "Name", "Age" ],
    [ "1", "Jane Doe", 29 ],
    [ "2", "John Doe", 35 ]
  ],
  "sheet_2": [
    ...
  ]
}
```

Figure 6: Example of XLS(X) to JSON transformer

2.2.3 Data Curation

Data curation is considered the maintenance and enrichment of data after the harvesting and transformation steps have been completed. In this first version of the prototypes, data curation has been focused on cleaning trajectory data based on GPS measurements.

2.2.3.1 Cleaning Trajectory Data

The GPS measurements obtained by affordable sensors can contain noise due to multiple reasons, among others:

- atmospheric and Ionospheric delays
- errors in the satellite and/or receptor clock
- multipath effect
- precision dilution
- selective Availability (S/A)
- anti-spoofing

Due to these effects the obtained measurements do not match exactly with the real positions of the sensors. This effect is especially important close to intersections, auxiliary parallel roads, and road junctions. In the case of Bilbao, these sensors are tracking the bicycles from the renting city service. In general, the location obtained from the GPS allows finding the position of the bikes within the city on many occasions they are exact enough to locate the road where it is travelling. However, some errors can occur. Map-Matching processes do not only correct the measurement noise but also reconstruct the intermediate points, producing a complete set of locations between the origin and the final destination of the trajectory.

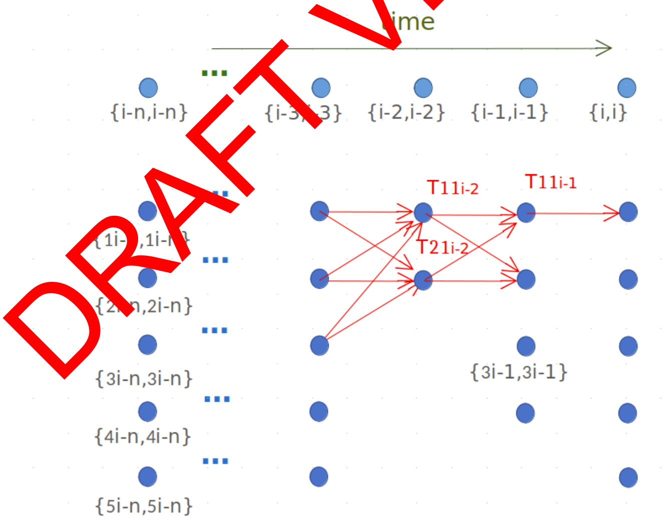

Figure 7: Trellis Diagram for the Hidden Markov Model used in the Map Matching Process.

The Map-Matching algorithm that we use in URBANITE consists in an independent implementation similar to the one introduced in [8]. This method works with GPS measurements and the timestamp at which each measurement is taken. From each of the measurements M_i a set of K possible candidates $\{C_i^k\}_{k=1}^{K}$ are obtained with the condition that these candidates correspond to points that define the roads. In general, the actual number of candidate values K changes from measurement to measurement depending on the density of roads close to M_i, i.e., if there is only a single road close to the measurement then $K = 1$, and the candidate corresponds to the point of the road which is closest to the measurement.

To each of these candidate points, C_i^k, an emission probability is assigned, O^k_i. In URBANITE we have chosen this probability to follow a normal distribution of the straight-line distance between the measurement and the candidate:

Emission Probability: $O^k_i \sim exp\left\{-{D_L(M_i, C_i^k)^2}\Big/{2\ \sigma^2}\right\}$

This probability captures the error within the measurement and basically means that a candidate is most probable if it is located closer to the obtained measurement. The easiest and simpler cleaning algorithms, like the known point-wise Map Matching, only use this probability to clean the trajectory measurements. In the case of URBANITE, it is also considered how probable it is to obtain a transition between candidates assigned to previous measurements. These transition probabilities, $T^{k\ l}_{i-1\ i}$, are assigned to candidate pairs, C_{i-1}^k, C_i^l, assigned to consecutive measurements *(i-1, i)* and they depend both on the straight-line distance $D_L\left(C_{i-1}^k, C_i^l\right)$, and the distance along the road network $D_R\left(C_{i-1}^k, C_i^l\right)$

Transmission Probability: $T^{k\ l}_{i-1\ i} \sim exp\left\{-{\left[D_R\left(C_{i-1}^k, C_i^l\right)\ - D_L\left(C_{i-1}^k, C_i^l\right)\right]^2}\Big/{\beta \Delta T^2}\right\}$

Using the emission and transmission probabilities the overall probability of a sequence of candidate points can be computed in the Trellis Diagram (see Figure 7). The actual route corresponds to the trajectory that contains the candidate points that belong to the sequence with higher probability. This allows estimating not only the last point, but this algorithm has the ability of correcting also previous estimates using the new information, a posterior measurement.

As we mentioned before, within the transmission probability the distance along the road network is used. This implies that the algorithm estimates what is the most probable route between 2 candidates. This is achieved using the open-source routing service OSRM[3] which considers the shortest route.

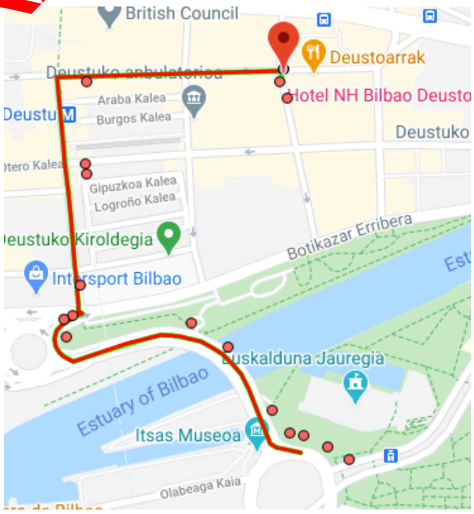

Figure 8: Result of the Map-Matching process applied to the bike GPS measurements.

[3] http://project-osrm.org/

2.2.4 Data Anonymization

The anonymization and pseud-anonymization of the data is key to the protection of privacy. A balance must be found between flexible solutions which are adaptable to each source and exploitation, but also easily manageable by the providers and users of this data, who not experts in ICT technologies. It is always a trade-off between anonymization and the loss of usefulness of the data in your application. Therefore, it is necessary for data providers and consumers to maintain an overview of the anonymization process and its subsequent implications.

ARX[4] is comprehensive open source software for anonymizing sensitive personal data, implementing a simple three-step process. It provides support for all common privacy criteria, as well as arbitrary combinations. It uses a series of well-known, transparent and highly efficient anonymization algorithms. In addition, it implements a carefully selected set of techniques that can handle a wide spectrum of data anonymization tasks, while being intuitive and easy to understand. In addition, it presents a multiplatform user interface aimed at non-expert users, with high visualization capacity, comparisons, etc. Finally, it provides a software library with an API, which facilitates integration with other components, as well as its use in isolation.

In order to cover a broad spectrum of privacy problems, it comes with implementations of commonly used privacy methods: k-Anonymity, that ensures that each register cannot be distinguished from at least k-1 other records regarding the quasi-identifiers defining groups of indistinguishable records (*equivalence class)*; k-Map, where the risks are calculated based on information about the underlying population, defined by the user or based on statistical frequency estimators; Average risk, that enforces a threshold on the average re-identification risk of the records; Population uniqueness, supported by statistical super-population models, is used to estimate characteristics of the overall population with probability distributions that are parameterized with sample characteristics (some methods can used as by Hoshino (Pitman), Zayatz and Chen and McNulty (SNB), other methods are: sample uniqueness, ℓ-Diversity, t-Closeness, δ-Disclosure privacy, β-Likeness, δ-Presence, Profitability or Differential privacy.

Additionally, the tool provides data quality analysis, estimating the utility of output data for the user scenarios, comparing the transformed dataset to the original input dataset, and statistics about the distribution of equivalence classes, suppressed records and other relevant metrics. Some attribute-level quality models implemented are: Precision, Granularity, Non-Uniform Entropy or Squared error.

At the time of writing this deliverable, no personal or sensitive personal data is being stored on the platform. For the next steps, it is expected to define the most suitable methods.

2.2.5 Components description

Table 1 shows an overview over the preparation/curation/anonymization/transformation software that is available in URBANITE. All components except ARX have been developed by the consortium.

Table 1: Component Overview

	Name	Description
Data Quality (data preparation and curation)	Checks and processes	Quality checks and calculations that are embedded in the data harvesting component and as batch processes over stored data.

[4] https://arx.deidentifier.org/

Transformer	CSV	Converts CSV into a JSON structure for further processing. Each row is mapped to a JSON array containing the field's values.
	XLS(X)	Converts XLS or XLSX files into a JSON structure for further processing. The data type must be configured in the applicable segment in the pipe descriptor. It can also be toggled whether to skip empty rows.
	JSON	Converts a given JSON structure into another JSON structure by means of JavaScript instructions. The script can be managed using Git (see transformation scripts below).
Misc.	Transformation Scripts	A simple GitLab repository that contains transformation scripts for use with the JSON transformer.
Data Curation	Algorithms	A map-matching method to reduce noise in GPS measurements.
Anonymization tool	ARX	It provides relevant data anonymization and pseudo-anonymization algorithms and supporting methods for the estimation of the data quality and usefulness of the outputs.

2.2.6 Technical specifications

Like the harvesting components described in deliverable D3.2 the data preparation and data transformation components covered in this document are also part of the Piveau Pipe concept. As such, all technical details described in the respective section in D3.2 also apply to these modules, i.e. they are written in Java and are based on the Vert.X[5] framework developed by the Eclipse foundation. The pipe functionality (parsing and manipulating the pipe descriptor) is provided by the Piveau Pipe Model library. The common endpoint each component exposes is implemented by the Piveau Pipe Connector library. Please refer to D3.2 for more details on the Piveau Pipe concept.

One special case is the JSON transformer. It features a JavaScript engine for running the transformation scripts. In order to cover as many language features as possible, it relies on the GraalVM[6] for providing a more sophisticated JavaScript engine than provided in the default JVM. Work is on the way to mitigate this dependency.

Besides, the data cleaning methods with application to trajectories, used for data curation, are implemented in Java, with invocations to the open-source routing service OSRM[7].

Finally, the ARX library for data anonymization is implemented in Java providing a UI. To use the basic features of ARX, the following libraries must be included: Colt, HPPC, Commons math, JHPL Newton-Raphson library, Commons validator; for the utility estimation: exp4j, Apache Mahout and SMILE, to add support for some machine learning algorithms. As previously mentioned, ARX offers a public API, whose documentation provides a detailed description of the different components and interfaces for loading data, defining data transformations, altering and manipulating data and processing the results of the algorithm.

[5] https://vertx.io/
[6] https://www.graalvm.org/
[7] http://project-osrm.org/

3 Delivery and usage

3.1 Package information

See the respective section in deliverable D3.2 for information about packaging.

3.2 Installation instructions

In order to integrate well into the URBANITE platform all components will be available as Docker images. However, before building the Docker images the corresponding JAR or WAR file needs to be created. The deployment of a service can be achieved using the three commands below. Note that curly brackets indicate that applicable values need to be substituted.

```
$> mvn clean package

$> docker build -t urbanite/{component-name} .

$> docker run -p {PORT}:8080 urbanite/{component-name}
```

Depending on the respective component a certain configuration may need to be applied, for example an API key. This can be achieved using environment variables, which can be passed to Docker containers like so:

```
$> docker run -e {ENV_VAR}={value} urbanite/{component-name}
```

3.3 User Manual

See the respective section in deliverable D3.2 for general information about where to find user manuals and API specifications.

3.3.1 JSON to JSON Transformer

Transformation scripts can be made available to the JSON to JSON transformer in three ways. Which one is applicable for the respective pipelines has to be configured in the Piveau Pipe descriptor. An overview over the available options is shown in Table 2.

Table 2: JSON Transformer Configuration

Method	Description	Sample Configuration

embedded	The script is integrated into the pipe descriptor.	In Pipe descriptor:
		`{`
		`  "scriptType": "embedded",`
		`  "script": "function transforming(input) { … }"`
		`}`

localFile	The script is placed in the scripts folder of the application before compilation.	In Pipe descriptor:
		`{`
		`  "scriptType": "localFile",`
		`  "path": "example.js"`
		`}`

repository	The script resides in a Git repository. The component frequently polls the repository for any changes. Requires	In Pipe descriptor:
		`{`
		`  "scriptType": "repository",`
		`  "path": "example.js"`
		`}`

	configuration at application level and in the Pipe descriptor.	Environment:
		`GIT_URI: https://gitlab.com/scripts.git`
		`GIT_USER_NAME: urbanite_service_account`
		`GIT_TOKEN: myAccessToken`
		`GIT_BRANCH: master`

3.4 Licensing information

The license terms for the software are under discussion among the consortium. AGPLv2 and AGPLv3[8] are being considered.

3.5 Download

The components that are included in the pipeline, i.e. data harvesting (described in D3.2), data preparation and data transformation are available in the GitLab maintained by Tecnalia[9]. ARX, as external tool, is available for download from the official site[10] and is maintained at GitHub[11].

[8] https://www.gnu.org/licenses/agpl-3.0.en.html

[9] https://git.code.tecnalia.com/urbanite/private/wp3-data-management/harvester

[10] https://arx.deidentifier.org/downloads/

[11] https://github.com/arx-deidentifier/arx

4 Conclusion

Overall, this document describes the technical details of the components involved in the preparation, transformation, curation and anonymization of data. Data curation, in this document considered to be the enrichment and maintenance of data, is covered in the v2 release of the components related to task 3.2. Anonymization is handled by the ARX software and is, akin to the curation modules, also integrated in the v2 release of the components. In the meantime, data provided by the pilots is expected to be already anonymized. Upon till now, various transformers have been developed: CSV to JSON, XLS(X) to JSON, and JSON to JSON. While the former two follow a static rule for conversion, the JSON to JSON transformer is customizable by means of JavaScript instructions. This makes it fit for tasks like the conversion into the common FIWARE models discussed in deliverable D3.4. Minor data preparation tasks are, if required by the individual data sources, directly handled in the importers/connectors. Due to the flexible design of the Piveau Pipe Concept outlined in D3.2 dedicated components handling the preparation of data could easily be integrated if required.

In conclusion this deliverable allows the reader to get an understanding of the technical solution(s) employed for the intermediated steps of data curation, preparation, transformation, and anonymization before storage as well as how to build and deploy the components involved.

5 References

[1] T. E. FhG, „URBANITE data structure and semantic model specification," 2020.

[2] T. E. FhG, „Data harvesting module and connectors implementation-v1," 2021.

[3] D. Pyle, Data preparation for data mining, morgan kaufmann, 1999.

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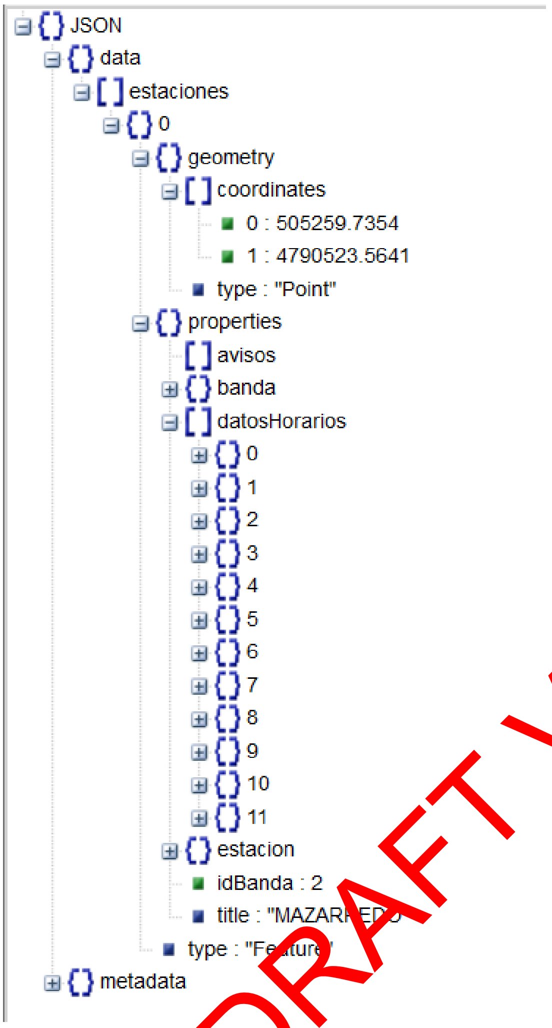
6 APPENDIX: Data transformation example

This section provides an example of a transformation script for air quality data in Bilbao Use Case.

The structure of the json that is the output of the data harvester is:



```
{ } JSON
  { } data
    [ ] estaciones
      { } 0
        { } geometry
          [ ] coordinates
            0 : 505259.7354
            1 : 4790523.5641
          type : "Point"
        { } properties
          [ ] avisos
          { } banda
          [ ] datosHorarios
            { } 0
            { } 1
            { } 2
            { } 3
            { } 4
            { } 5
            { } 6
            { } 7
            { } 8
            { } 9
            { } 10
            { } 11
          { } estacion
          idBanda : 2
          title : "MAZARREDO"
        type : "Feature"
  { } metadata
```

The JavaScript file used for the transformation is:

```
function transforming(input) {
  var result = [];
  var data = input.data;
  var stations= data.estaciones;
  for (var i in stations) {
    var station = stations[i];
    var output = {
      "@context": [
        "https://smartdatamodels.org/context.jsonld",
        "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld"
      ],
    };
    var lastMeasureDate = station.properties.datosHorarios[0].fechaHoraUltimaMedidaHoraria;

    var procesedDate = lastMeasureDate.replaceAll(" ","");
    procesedDate = procesedDate.replaceAll("/","");
    procesedDate = procesedDate.replaceAll(":","");
    output.id = "urn:ngsi-ld:AirQualityObserved:" +
station.properties.estacion.codigoEstacion+":"+procesedDate;//confecha

    output.type = "AirQualityObserved";

    var loc = new Object();
    var coordinates = [];
    coordinates.push(station.properties.estacion.coordenadaLat);
    coordinates.push(station.properties.estacion.coordenadaLon);
    loc.coordinates = coordinates;
    loc.type = "Point";
    output.location = loc;
    //yyyy-MM-dd'T'HH:mm:ss
    var  datetime = lastMeasureDate.split(" ");
    var datepart = datetime[0].split("/");
    var timepart = datetime[1].split(":");
    output.dateObserved =datepart[2]+"-"+datepart[1]+"-
"+datepart[0]+"T"+timepart[0]+":"+timepart[1]+":00";//lastMeasureDate;
    var contaminantes = station.properties.datosHorarios;
    for (var icont in contaminantes) {
      var contaminante = contaminantes[icont];
      var nombreContaminante = contaminante.contaminante.nombreContaminante;
      switch (nombreContaminante) {
        case "NO":
          output.no = contaminante.ultimoValorHorario;
          break;
        case "CO":
          output.no = contaminante.ultimoValorHorario;
          break;
        case "NO2":
          output.no2 = contaminante.ultimoValorHorario;
          break;
        case "NOX":
          output.nox = contaminante.ultimoValorHorario;
          break;
        case "PM10":
          output.pm10 = contaminante.ultimoValorHorario;
          break;
        case "SO2":
          output.so2 = contaminante.ultimoValorHorario;
          break;
        default:
          break;
      }
    }

    result.push(output);
  }

  return {
    "metadata": input.metadata,
    "data": result
  };
}
```

And the output of the transformer, that is a JSON in NGSI-LD format compliant to `airQualityObserved` FIWARE data model is:

```
{
  "metadata" : {
   "@graph" : [ {
    "@id" : "_:b0",
    "@type" : "foaf:Organization",
    "homepage" : "https://urbanite-project.eu/",
    "name" : "URBANITE"
   }, {
    "@id" : "_:b1",
    "@type" : "accessRights",
    "label" : "public"
   }, {
    "@id" : "http://urbanite-project.eu/ontology/dataset/bilbao_airquality_JULY_2021",
    "@type" : "dcat:Dataset",
    "accessRights" : "_:b1",
    "description" : {
     "@language" : "en",
     "@value" : "Air Quality information for Bilbao, downloaded at 2021-07-21."
    },
    "issued" : "2021-07-21T07:07:58.553410200Z",
    "modified" : "2021-07-21T07:07:58.553410200Z",
    "publisher" : "_:b0",
    "title" : {
     "@language" : "en",
     "@value" : "Bilbao Air Quality for 2021 7"
    },
    "distribution" : "http://urbanite-project.eu/ontology/distribution/airquality/bilbao_2021721",
    "keyword" : [ "Bilbao", "Air Quality", "2021", "JULY" ],
    "theme"        :        [        "http://publications.europa.eu/resource/authority/data-theme/REGI",
"http://publications.europa.eu/resource/authority/data-theme/TRAN" ]
   }, {
    "@id" : "http://urbanite-project.eu/ontology/distribution/airquality/bilbao_2021721",
    "@type" : "dcat:Distribution",
    "description" : {
     "@language" : "en",
     "@value" : "NGSI-LD representation of FIWARE Air Quality data model bilbao_210720210500"
    },
    "format" : "http://publications.europa.eu/resource/authority/file-type/JSON",
    "license" : "http://publications.europa.eu/resource/authority/licence/CC_BY",
    "title" : {
     "@language" : "en",
     "@value" : "JSON-LD"
    },
    "accessURL"                                                                                  :
"https://urbanite.esilab.org:8443/data/getTDataRange/airQualityObserved/bilbao?startDate=2021-
7-21T00%3A00%3A00.000Z&endDate=2021-7-21T23%3A59%3A00.000Z"
   } ],
   "@context" : {
    "publisher" : {
     "@id" : "http://purl.org/dc/terms/publisher",
     "@type" : "@id"
    },
    "accessRights" : {
```

```
    "@id" : "http://purl.org/dc/terms/accessRights",
    "@type" : "@id"
  },
  "keyword" : {
    "@id" : "http://www.w3.org/ns/dcat#keyword"
  },
  "theme" : {
    "@id" : "http://www.w3.org/ns/dcat#theme",
    "@type" : "@id"
  },
  "modified" : {
    "@id" : "http://purl.org/dc/terms/modified",
    "@type" : "http://www.w3.org/2001/XMLSchema#dateTime"
  },
  "issued" : {
    "@id" : "http://purl.org/dc/terms/issued",
    "@type" : "http://www.w3.org/2001/XMLSchema#dateTime"
  },
  "description" : {
    "@id" : "http://purl.org/dc/terms/description"
  },
  "title" : {
    "@id" : "http://purl.org/dc/terms/title"
  },
  "distribution" : {
    "@id" : "http://www.w3.org/ns/dcat#distribution",
    "@type" : "@id"
  },
  "name" : {
    "@id" : "http://xmlns.com/foaf/0.1/name"
  },
  "homepage" : {
    "@id" : "http://xmlns.com/foaf/0.1/homepage"
  },
  "label" : {
    "@id" : "http://www.w3.org/2000/01/rdf-schema#label"
  },
  "license" : {
    "@id" : "http://purl.org/dc/terms/license",
    "@type" : "@id"
  },
  "format" : {
    "@id" : "http://purl.org/dc/terms/format",
    "@type" : "@id"
  },
  "accessURL" : {
    "@id" : "http://www.w3.org/ns/dcat#accessURL",
    "@type" : "@id"
  },
  "schema" : "http://schema.org/",
  "dcatap" : "http://data.europa.eu/r5r/",
  "adms" : "http://www.w3.org/ns/adms#",
  "spdx" : "https://spdx.org/rdf/terms/#",
  "gsp" : "http://www.opengis.net/ont/geosparql#",
  "owl" : "http://www.w3.org/2002/07/owl#",
  "org" : "http://www.w3.org/ns/org#",
      "xsd" : "http://www.w3.org/2001/XMLSchema#",
      "skos" : "http://www.w3.org/2004/02/skos/core#",
      "rdfs" : "http://www.w3.org/2000/01/rdf-schema#",
      "hydra" : "http://www.w3.org/ns/hydra/core#",
      "dct" : "http://purl.org/dc/terms/",
      "v" : "http://www.w3.org/2006/vcard/ns#",
      "time" : "http://www.w3.org/2006/time#",
      "dcat" : "http://www.w3.org/ns/dcat#",
      "odrl" : "https://www.w3.org/TR/odrl-vocab/#",
      "locn" : "http://www.w3.org/ns/locn#",
      "prov" : "http://www.w3.org/ns/prov#",
      "foaf" : "http://xmlns.com/foaf/0.1/",
      "gmd" : "http://www.isotc211.org/2005/gmd#"
    }
  },
  "data" : [ {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:62:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.26750551179745, -2.935188110338201 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00",
    "no" : 0,
    "no2" : 8,
    "nox" : 8,
    "pm10" : 33.08,
    "so2" : 0
  }, {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:3:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.254591056506432, -2.902376115931137 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00",
    "no" : 1,
    "no2" : 9,
    "nox" : 11,
    "pm10" : 31.71,
    "so2" : 3
  }, {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:12:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.245553729819484, -2.960475856567045 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00",
    "no" : 3,
    "no2" : 10,
    "nox" : 14,
    "pm10" : 24.75,
    "so2" : 4
  }, {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:8:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.26522199716327, -2.9475439999557134 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00"
  }, {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:7:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.28099012364825, -2.953278416670214 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00"
  }, {
    "@context" : [ "https://smartdatamodels.org/context.jsonld", "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context.jsonld" ],
    "id" : "urn:ngsi-ld:AirQualityObserved:6:210720210500",
    "type" : "AirQualityObserved",
    "location" : {
      "coordinates" : [ 43.25880286639215, -2.945656664175787 ],
      "type" : "Point"
    },
    "dateObserved" : "2021-07-21T05:00:00",
    "no" : 5,
    "no2" : 14,
    "nox" : 21,
    "pm10" : 31.71,
    "so2" : 1
  } ]
}
```