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INTEGREEN

Action 4: Implementation & Integration

P.4.1.3

Environmental stations front-end prototype

Project Coordinating Beneficiary	Municipality of Bolzano
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1 Introduction

1.1 Purpose of the document

The purpose of this document is to present the technical details of the several data sources located at the Supervisor Centre of the INTEGREEN system that have the function to collect on a real-time basis different data types from external sources. (Figure 1).

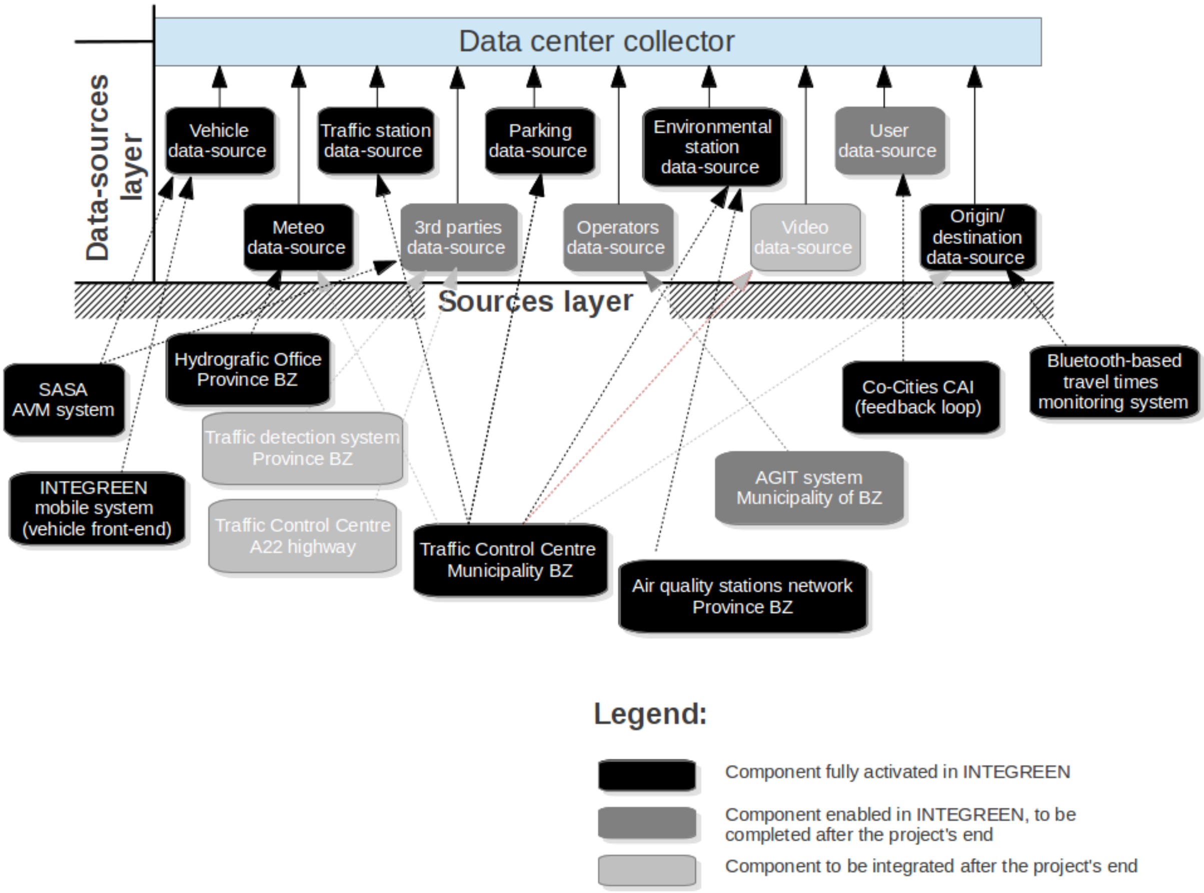

Figure 1: The data source layer environment of the Supervisor Centre of the INTEGREEN system specified during the design action [1].

This report covers the presentation of all data sources, except for the vehicle data source which is indeed presented in protype deliverable P.4.1.2 [2].

1.2 Document structure

The document is structured in one single chapter presenting mainly the functionalities of: (i) the environmental station and meteo data sources, which automatically collect data from the existing air pollution and meteorological monitoring stations owned by the Autonomous Province of Bolzano and installed in the city; (ii) the origin / destination data source, which collects the data from the Bluetooth vehicular travel times monitoring system; (iii) the 3rd-party data source which collect the variety of data now at disposal at the Traffic Control Centre of the Municipality of Bolzano (parking, traffic, air pollution). The presentation of each data source covers not only the software component running at the Supervisor Centre fetching the data on a real-time basis, but also the field equipment that perform the measurements on a continuous basis.

2 Prototype description

The data source layer is characterized by a set of unique and independent software entities which are responsible to collect data from a selected set of external sources providing different data types in the field “traffic” and “environment” and to forward the pre-validated data to the Data Center Collector. This latter function is mostly the same for all these components, take advantage of the common code library shared with other components of the data management unit [3]. Together with the data sources, a detailed glance to each source is given as well, in particular to those installed in the scope and with the funding of the INTEGREEN project.

The implementation of this layer of the INTEGREEN system can be summarized as follows:

- **Environmental and meteo data sources**. Two client applications automatically collect the published data by the Local Agency for the Environment and the Hydrographic Office of the Province of Bolzano, respectively, on a regular basis and provide it to the data center layer. These interfaces have been opened ad-hoc for the Supervisor Centre, i.e. no other authority has at present access to all this state-of-art environmental information.

- **Bluetooth vehicular travel times monitoring system**. This system has been fully implemented in the INTEGREEN project. The complete prototype includes:

    - the **roadside detectors**, including the logic for the **remote communication** of the data to the Supervisor Centre through the Origin/Destination data source;

    - all the elaboration chain needed to determine an **estimation of the travel time** between two consecutive detection points, as illustrated in P.4.1.1 [3];

    - a simple **web application** (**BZTraffic**) which presents the estimated vehicular travel times in the city [4].

- **3rd party data source**. This software component implements the interface with the Traffic Control Centre of the city of Bolzano, which is now in the condition to provide four classes of data: (i) real-time information related to the main **parking areas** of the city; (ii) real-time data related to the **vehicular transits** (identification of the class and speed of all vehicles), which are in some cases coupled with **meteorological information**; (iii) real-time **air pollution data**, measured by new roadside measurement stations; and (iv) real-time data related to the **bicycles transits** in correspondence of a specific pilot monitoring point.

2.1 Connection to existing air pollution stations

The Environmental Station Data Source has implemented through the **Spring** framework, which provides a comprehensive programming and configuration model for modern Java-based enterprise applications [5]. This software component is mainly a **SOAP client** that periodically request data from SIAG, the local e-government company owned by the Province of Bolzano, which is in charge of the storage and management of all the data collected by the automatic measurement stations owned by the provincial departments. The SOAP server of SIAG has been customized in order to allow the Environmental Data Source to deliver to the INTEGREEN Supervisor Centre the hourly NO_2 official averages related to the two traffic-exposed air pollution stations in the city of Bolzano [1]- [6]. This is practically what is officially available online on the web portal of the Local Agency of the Environment.

Figure 2: The two official air quality stations in Bolzano delivering automatically air pollution data to the Supervisor Centre (Adriano Square, on the left; Claudia Augusta Street, on the right).

This data is updated on an hourly basis, and typically provided 5-15 minutes after the end of a solar hour (e.g. monitored period 11:00-12:00 -> new values available at 12:15 at latest). Since the refresh instant can vary to case to case, the client has been calibrated in order to ask for an update every 5 minutes.

This web-service uses a simple basic authentication approach over **SSL encrypted channel** for secure transmission. The type of account used is ID-Management Südtirol and username and password were released to TIS, which manages the automatic web service, during the activation launch of the service. The implementation of the SOAP client was carried out with a component of the Spring framework, *spring-ws*. This is the configuration of the service and the required documentation to understand it:

```
   <bean
class="org.springframework.ws.soap.saaj.SaajSoapMessageFactory"
id="messageFactory" />

    <oxm:jaxb2-marshaller id="marshaller">

           <oxm:class-to-be-bound
name="it.siag.services.luft.remarks_v1_0.GetHourlyData"/>
```

```
            <oxm:class-to-be-bound
name="it.siag.services.luft.remarks_v1_0.GetHourlyDataResponse"/>

            <oxm:class-to-be-bound
name="it.siag.services.luft.luft_v1_0.Remark"/>

    </oxm:jaxb2-marshaller>

    <bean
class="org.springframework.ws.client.core.WebServiceTemplate"
id="webServiceTemplate">

        <constructor-arg ref="messageFactory"/>

        <property name="marshaller" ref="marshaller"/>

        <property name="unmarshaller" ref="marshaller"/>

        <property name="messageSender">

            <bean
class="org.springframework.ws.transport.http.HttpComponentsMessageSe
nder">

                <property name="credentials">

                    <bean
class="org.apache.http.auth.UsernamePasswordCredentials">

                        <constructor-arg value="****:*******"/>

                    </bean>

                </property>

                <property name="connectionTimeout" value="60000"/>

                <property name="readTimeout" value="60000"/>

            </bean>

        </property>

        <property                                     name="defaultUri"
value="https://air.ws.siag.it/Luft_v1"/>

    </bean>
```

The web-service is available and maintained 24/7; only in rare and very specific cases (e.g. software updates, application upgrades, etc.), TIS and SIAG have jointly agreed the possibility to have limited downtime periods, for a maximum of 24 [hours]. Urgent service downtime are however possible, but for a maximum period of 60 [minutes]. The SOAP server typically replies with a response time which is at maximum 1 [s]; in particular situations the latency could reach at maximum 20 [s]. The implementation details of the web-service can be summarized as follows:

- **test environment**:
  - WSDL: https://test-luft.ws.siag.it/wsdl/luft_v1.wsdl
  - End point: https://test-luft.ws.siag.it/luft_v1
- **production environment**:
  - WSDL: https://luft.ws.siag.it/wsdl/luft_v1.wsdl
  - End point: https://luft.ws.siag.it/luft_v1

2.2 Connection to existing meteorological stations

The meteo data source automatically requests the meteorological data measured by the measurement station of Bolzano [1].

Figure 3: The official meteorological station of the city of Bolzano delivering automatically meteorological data to the Supervisor Centre.

In this case, as specified during the design process, the data are not taken through SIAG but are published as a downloadable file in the **ZRXP** format, which is the automatic output format of the meteorological measurement equipment. The end point is :

http://www.provinz.bz.it/hydro/exchange/uploads/Bozen_Integreen.zrx

This is an unconventional format for web-based data transfer; this is indeed the format used for the exchange of meteorological measurements [1]. No available open source libraries have been found that can provide comfortable parsing capabilities, thus a custom parser had to be created. A library "*zrx2json.jar*" was created to parse the data from ZRX format to the more common format **JSON**. The structure was modified slightly for better visibility and better understanding of the standard. The meteo datasource uses this library to do the parsing of the data and at the same time to add custom parameters introduced by the Hydrographical Office. The same data delivery scheduling as well as the XML-RPC client libraries used by the other data sources are followed to push the data periodically.

On the other side, the advantage is that the data frequency is in this case much higher, because the interface is in practice with the specific meteorological station. The interval between two data records is 5 [minutes]. The data types covered are:

- **wind speed & direction and wind gust speed;**
- **global radiation;**
- **sunshine duration;**
- **barometric pressure;**
- **air temperature;**
- **relative humidity;**
- **precipitation amount.**

2.3 Bluetooth vehicular travel times monitoring system

A brief presentation of the several hardware and software vehicular travel times monitoring system based on Bluetooth technology is given in the next paragraphs, as well as an analysis of the current deployment status.

2.3.1 The roadside unit prototype

The roadside unit is a hardware device responsible of the non-invasive scanning of the vehicular traffic, as specified in [1]. Each Bluetooth detection is logged in a local database through an anonymous identifier, and in the meanwhile a local scheduler is executed to synchronize the data gathered by the probe with the data stored at the Supervisor Center. Each roadside fixed station is part of a virtual private network (VPN) and it delivers remotely the data to the central system through a Wi-Fi or 3G connection.

The hardware and software components are the following:

- **Rasperry-Pi**. The Raspberry Pi is a small, chip and powerful credit-card-sized computer [7]. It costs US$ 25 (Model A) and US$ 35 (Model B) and is powered by an ARM processor (700 [MHz]). It can storage 256 [Mbytes] (Model A, Model B rev2) and 512 [Mbytes] (Model B rev1). Our prototype uses the **Model B rev1** due to the presence of two USB ports, one connected to the Bluetooth doongle and the other to the 3G / Wi-FI device.

Figure 4: The battery-powered version of the Bluetooth detector prototype.

Figure 5: The Rasperry-Pi model B rev1 used in the Bluetooth detector prototype.

- **Bluetooth dongle**. It is the key part of the detector, since it is responsible for the active inquiry of the surrounding Bluetooth devices. The Bluetooth protocol has 3 different major power classes (tagged as “1”, “2” and “3”) [8]. Class “1 dongles give the largest communication range, and thus the best results in terms of detection capabilities, but however consumes much more energy. The communication range depends on several factors, the most important being the antenna design, the propagation conditions and the material coverage. The choice of the dongle and more generally of all Bluetooth scanning subsystem must be carefully selected as a function of the selected station position and the number of roadways involved.

Figure 6: Bluetooth dongles for the Bluetooth detector prototype.

- **Power supply**. The prototype is available both as:
    - **battery-powered** 12 [V] - 9.0 [Ah] unit which can give up to three-four days of life time and thus can be used for short period field investigations (Figure 7);
    - **permanent installation** through a connection with the continuous power supply. The fixed deployments will use of course this kind of configuration.

Figure 7: The battery unit for the battery-based version of the Bluetooth detector prototype.

- **DC-DC converter**. In the battery-powered version of the device, a common car cigarette lighter adapter with USB port is used as well. The adapter convert the 12V of the battery to the 5V needed by the Raspberry Pi.

Figure 8: The DC-AC converter for the battery-based version of the Bluetooth detector prototype.

- **Box cointainer**. It is a simple impermeable box, with protection class IP56. The dimension of the box varies slightly depending on the installation needs.

- **Bluelog**. Bluelog is an open source Bluetooth scanning software available at www.digifail.com designed to discover nearby devices as quickly as possible, and which is automatically executed on the Rasperry Pi.

It is important to underline the effort spent on the minimization of the power consumption of the Rasperry Pi. For example, for its 3V3 rail ituses a linear regulator. This kind of components dissipates approximately one third of the energy as heat. In our case this is a bit of waste that e.g. reduces the battery lifetime and thus the time-to-live of the battery-version of the Bluetooth detector. To solve this problem, the linear regulator was substituted by a more efficient switch mode power. This solution led to a reduction in the power consumption of approximately 25%.

Figure 9: The box container of the Bluetooth detector prototype.

2.3.2 Roadside installations

A precise installation plan was defined in [1], and has been followed without deviations during the implementation phase. At present the installed detectors are placed at the locations graphically illustrated in Figure 10. It is important to underline that three more detectors have been added with respect to the plan defined during the design phase, i.e. the ones on the route Castel Firmiano – Vittorio Veneto Street – Rosmini Street. In this way, it is possible to monitor the incoming traffic flows coming from west through Castel Firmiano gate, and understand if there are some deviations with the main gate represented by Druso Street – Adriano Square.

Figure 10: The map with all present Bluetooth installations.

The Bluetooth detectors are installed as illustrated in Figure 11, in which the TIS installation is reported. Detectors are always located in one of the available cabinets destined to roadside traffic lights controllers, as already identified in the specification phase. This choice has been made for two reasons: (i) easy availability of the power supply; (ii) minimization of security risks; (iii) correct functioning of the measurement process.

Figure 11: The Bluetooth detector installation in correspondence of TIS headquarters, in Siemens Street.

2.3.3 The O/D Data Source prototype

The ODDS has been developed entirely by TIS. Data are sent to this data source from all the stations deployed in the city of Bolzano. Each station periodically sends the data package which contains a list of the Bluetooth devices detected in the last monitoring period. The data delivery phase has been developed in order to avoid any data lost: more specifically, at every data delivery each station sends to the data source all the data that are not available remotely. That approach is achieved through the use in each single station of a local database to store the data gathered among each delivery; only when data reception is acknowledged by the data source then the transmitted data is locally removed for security reasons in the monitoring stations. In order to accomplish this synchronization process, the data source provides a method to the roadside station that return the timestamp of the last record stored in the data center layer of the INTEGREEN Supervisor Centre.

This Bluetooth detections are sent by the roadside detectors to the ODDS periodically every five minutes in **JSON** format, following the specifications give in D.3.1.1. This approach is different from the ones implemented in the other data sources since in this case it is the external actor that pushes data to the data source component

2.4 Interface with Traffic Control Centre the Municipality of Bolzano

As already indicated in this report, the interface with the Traffic Control Centre of the Municipality of Bolzano at present allows the real-time exchange of four different data types: (i) parking information; (ii) traffic (or traffic + meteorological) data; (iii) air pollution measurements; and (iv) bicycles detections. The present report does not cover the interface with the real-time parking information, and focuses only to other three data types.

2.5.1 New and enhanced traffic and air pollution installations

In the scope of the project, one of the main activities has been to ensure the ability to measure vehicular transit in a reliable way at a certain number of key locations. These measurements are carried out through traditional inductive loops positioned under the road surface. All identified traffic monitoring stations have been properly activated or repaired during the implementation phase, as specified in D.3.1.1 [1]. The **traffic data** collected for each vehicular transit are the following:

- **timestamp;**
- **ID;**
- **travel direction;**
- **travel lane;**
- **speed [km/h];**
- **length [cm];**
- **headway [s];**
- **gap [m];**
- **vehicle category, according to the 9+1 “ITALY 10” classification.**

Aggregated traffic data contain on the other side:

- **average speed value (and standard deviation);**
- **average speed for each vehicle category;**
- **total number of transits;**
- **total number of transits for each vehicle category;**
- **average gap (and standard deviation);**
- **average headway (and standard deviation);**

- **average percentage of time of occupancy of the inductive loop area;**
- **average vehicle length.**

What is more interesting is the introduction in the city of Bolzano of two novel monitoring sites exploiting the concept of “fixed integrated monitoring of traffic and environmental conditions”. These integrated monitoring stations can make measurements on traffic, air pollution concentrations and meteorological status. The two implementation were expected to take place one within the industrial area and one near the fixed air pollution station in Claudia Augustra Street for cross-verification analysis of the air pollution data. During the implementation process, a different installation location for the new monitoring stations had to b identified. This requirement has emerged because of the opening of urgent and unpredictable road work sites in correspondence of the chosen installation points. Traffic and air pollution correlation analysis would have been therefore strongly affected by these disruptions, and would have led to biased and non-representative results.

Different locations within the reference test area have been therefore selected, as illustrated in Figure 12:

Figure 12: Overall view of the integrated traffic – air pollution roadside stations purchased through the INTEGREEN project.

- one station installed in Siemens Street, an important **access point** of the city, directly linked to the **industrial area**, not far from the Bluetooth detector "TIS;
- one station in correspondence of Roma Street, and in particular at one of the most important **traffic light intersection** of the city, located within a densely populated residential area, not far from the official air pollution station of Adriano Square.

Together with the above traffic measurements, these stations are capable of measuring the following environmental parameters, according to the technical instrumentation deploying certain monitoring technologies as described in D.3.1.1:

- **Air pollutants**: NO_2; NO_X; CO; O_3; PM_{10}; $PM_{2.5}$; VOC and other secondary air pollutants such as benzene;
- **Meteorological parameters**: wind speed and direction; air temperature and relative humidity; solar radiation.

The installation in Siemens Street

The installation in Siemens Street of the air pollution and meteorological sensors has been carried out by taking advantage of an existing portal on which a traffic light system is currently mounted (Figure 13).

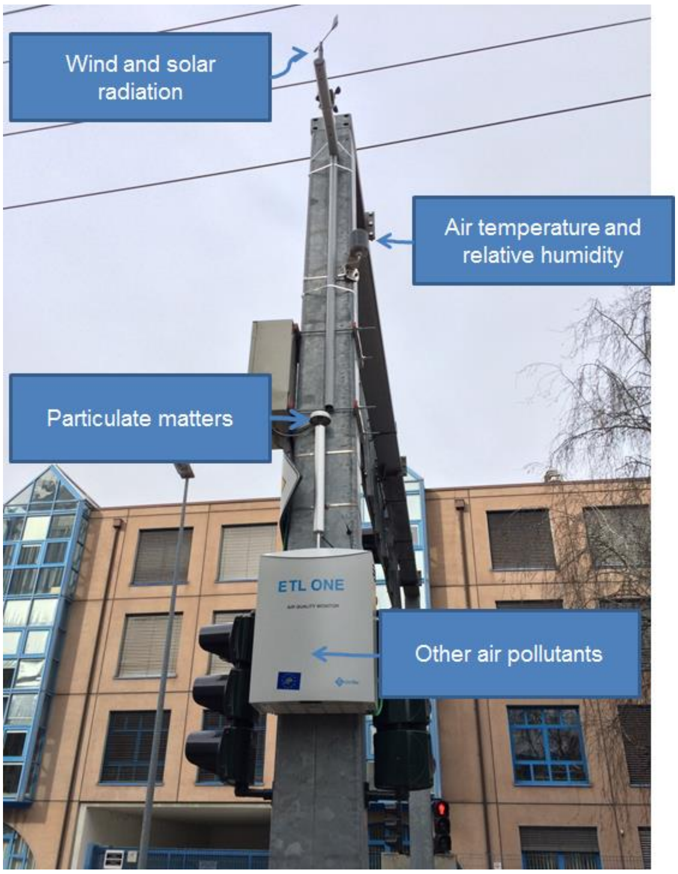

Figure 13: The integrated traffic – air pollution roadside station of Siemens Street.

Different sensors are mounted at different heights, according to reference measurement recommendations. The air pollution sensors are all contained in the box "ETL ONE", except for the particulate matter measurement equipment.

The installation in Roma Street

The installation in Siemens Street has been carried out a little bit differently, since it has not been possible to install all the equipment on the same traffic lights portal. In this case, air pollution sensors have been installed on a near street light, while the meteorological sensors only have been place on top of the traffic lights portal (Figure 14).

Figure 14: The integrated traffic – air pollution roadside station of Roma Street.

The connection between the monitored stations and the Traffic Control Centre is ensured where possible through the network in fibre channel of the Municipality of Bolzano or the dedicated radio channel [6]. For the air pollution measurements, which are handled separately by the ETL ONE box, this data are transmitted through cellular network.

Last but not least, in the scope of the project the interface with the **bicycle counter** already in function since several years has been implemented (Figure 15). The data displayed on the Variable Message Signs are the number of detections from the installation date and the number of detections in the last day. What is to the Traffic Control Centre is however the number of detections in the last 5 [minutes].

Figure 15: The automatic bicycle counter.

2.5.2 The 3rd-Parties Data Source Prototype

During the implementation of the interfaces with the Traffic Control Centre, a significant deviation with respect the design choices of D.3.1.1 has been decided. Instead of implementing the Traffic Data Source for the retrieval of the traffic data (including bicycle detections), and to extend the meteo DS and environmental DS for the gathering of the meteorological and air pollution data, respectively, it has been decided to follow a more scalable approach, which has revealed to be necessary in light of the future installations that the Municipality of Bolzano has in plan to add after the INTEGREEN project.

For this reason, TIS together the external assistance service company Famas System, which has been give the task to improve the overall roadside monitoring monitoring network and to create the web interfaces to the Supervisor Centre, have decided to implement together an instance of the **3rd –parties Data Source** (3PDS), as defined in the requirements'analysis. This choice has also determined the need to follow a different protocol for the exchange of data, i.e. **SOAP** instead as XML-RPC as it is used for the exchange of the real-time parking information.

The **end point** for the requests of the 3PDS to the Traffic Control Centre is the following:

http://5.97.32.102:5001/DataDispatcherWebServices.asmx

For security reasons, the proper access is guaranteed only to the IPs associated to the servers where at present the 3PDS is executed. In order to accomplish this, a proper rule had to be inserted in the programming of the firewall of the Traffic Control Centre local area network.

The available methods are the following:

- **get_station_ID**: returns the IDs of all monitoring stations that the central systems of the Traffic Control Centre are currently managing;
- **get_metadata_station**: in order to call the method, the station ID must be given. The method returns different information, such as its position and its type, which are present can be belong to one of the following categories:
    - **traffic station;**
    - **meteorological station;**
    - **traffic + meteorological station;**
    - **bicycle station;**
    - **air pollution station;**
- **get_data_types:** in order to call the method, the station ID must be given. The method returns the list of parameters which are measured by the requested station. Each data type is characterized in terms of:
    - **measurement unit;**
    - **measurement interval.**
- **get_data:** in order to call the method, the station ID must be given as well as the IDs of the data types associated to it (which can be a subset of all data types managed). The method returns the last value associated to the requested data types. Such measurement are coupled with:
    - **timestamp;**
    - **measurement unit;**
    - **accuracy.**
- **get_data_historical**: similar as get_data, but with the possibility to give as input the starting and ending time of the desired time interval. The method returns the whole set of values (with some limitations in the amount of data, if the time interval is too big) associated to the requested data types.

The 3PDS has been implemented and executed as suggested in the requirements' definition:

requests every 5 [minutes] for the traffic data; every 15 [minutes] for the environmental data. The data are then simply parsed and delivered to the Data Center Collector through XML-RPC.

Conclusions

The report has presented the final implementation of the entire data source layer of the Supervisor Centre. This part of activities has significantly extended with respect to the project planning phase, since it deals with many monitoring stations and not only with the interface with the environmental stations front-end.

The implementation of this layer of the INTEGREEN system can be summarized as follows:

- **Environmental and meteo data sources**. Two client applications automatically collect the data published by the Local Agency for the Environment (air pollution data) and the Hydrographic Office of the Province of Bolzano (meteorological data), on a regular basis and provide it to the data center layer. These interfaces have been opened ad-hoc for the Supervisor Centre, i.e. no other authority has at present access to all this state-of-art environmental information.

- **Bluetooth vehicular travel times monitoring system**. This system is a novelty introduced in the INTEGREEN project. In this report, only the **roadside detectors**, including the logic for the **remote communication** of the data to the Supervisor Centre through the Origin/Destination data source are covered (all the elaboration chain needed to determine an **estimation of the travel time** between two consecutive detection points is explained in P.4.1.1 [3] and the the visualization of the estimated vehicular travel times in the city through the **web application** (**BZTraffic**) is discussed in P.4.1.5 [4]

- **3rd party data source**. This software component implements the interface with the Traffic Control Centre of the city of Bolzano, which is now in the condition to provide four classes of data: (i) real-time information related to the main **parking areas** of the city; (ii) real-time data related to the **vehicular transits** (identification of the class and speed of all vehicles), which are in some cases coupled with **meteorological information**; (iii) real-time **air pollution data**, measured by new roadside measurement stations; and (iv) real-time data related to the **bicycles transits** in correspondence of a specific pilot monitoring point. During the implementation process, all monitoring stations have been installed, connected or properly repaired. In particular, two integrated monitoring stations capable of measuring at the some point traffic, meteorological and air pollution conditions have been introduced.

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