LIFE+10 ENV/IT/000389

INTEGREEN

Action 4: Implementation & Integration

P.4.1.2

Vehicle-to-centre front-end prototype

Project Coordinating Beneficiary	Municipality of Bolzano
Project Associated Beneficiary n.2	TIS innovation park (TIS)
Project Associated Beneficiary n.3	Austrian Institute of Technology (AIT)

Document history

Date	Document Author(s)	Document Contribution
31/03/14	Roberto Cavaliere, Paolo Valleri, Stefano Seppi (TIS), Reinhard Kloibhofer, Wolfgang Ponweiser (AIT)	First document version submitted to the EC
31/05/15	Roberto Cavaliere, Patrick Bertolla (TIS), Reinhard Kloibhofer (AIT)	Second and final document version submitted to the EC. Contributions to the document have been given by the stakeholder SASA as far as the interface with the urban public transportation data is concerned.

Dissemination level: CO[1]
Delivery month: 45
Status: submitted to the EC

[1] **PU** = Public; **CO** = Confidential (for members of the consortium only, including the European Commission); **RE** = Restricted, i.e. only a selected target of stakeholders defined by project consortium and validated by European Commission can access to the document. The final dissemination level will be defined in cooperation between the INTEGREEN consortium and the European Commission.

Table of Contents

Table of Figures

Table of Tables

1 Introduction

1.1 Purpose of the document

The purpose of this document is to present the first version of the prototype of the vehicle data source of Supervisor Centre of the INTEGREEN system (in the original system architecture denoted as *vehicle-to-centre front-end*), as designed in Action n.3 (Figure 1).

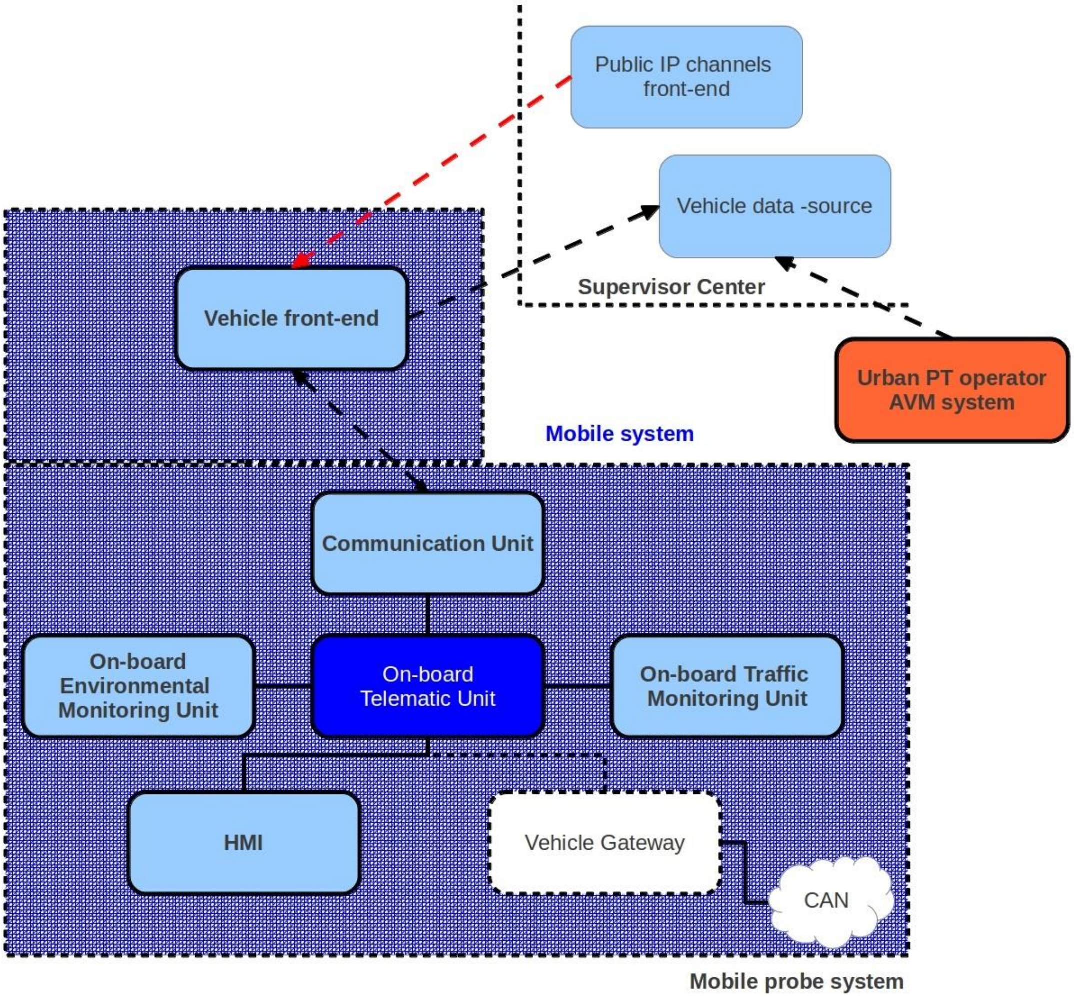

Figure 1: The vehicle data source of the Supervisor Centre of the INTEGREEN system [1].

It is important to underline that this report does not focus on the communication between the mobile probe system and the vehicle front-end. The prototype of this system component is indeed presented in protype deliverable P.4.2.3.

1.2 Document structure

The document is structured in one single chapter presenting the functionalities of the vehicle data source that have been already implemented, covering both the interface with the INTEGREEN mobile system as well the interface with the *Automatic Vehicle Monitoring* (AVM) system of the urban public transportation service provided by SASA.

2 Prototype description

The vehicle data source is a software component written in Java language that is capable to receive on a real-time basis data from different external sources, i.e.:

- **the INTEGREEN mobile system**, which include all vehicles mounting the prototype on-board units developed by AIT;
- **the AVM system of SASA**, which include (among others) all the buses offering the road public transportation service in Bolzano.

2.1 Interface with mobile system

The communication with the mobile system has been implemented through a periodic **HTTP POST** (**once a minute**) containing JSON data, following the specifications given in [1]. The implemented options are the following:

- **HTTP post with file containing valid JSON**, that must be delivered to http://ds.integreen-life.bz.it/vehicleds/file ;
- **HTTP post with plain JSON,** that must be delivered to http://ds.integreen-life.bz.it/vehicleds/json.

Vehicle Data must have the same structure as provided in this example:

```
{
     "carData":[{
        "vehicle_id":"someString" ,
        "values":[{
              "ts_ms":1371726911000, //time in milliseconds
              "O3":134.0, //o3 emissions
              "gps_lon":16.5689946776,
              "gps_lat":48.1902315817
              …
        }]
     }]
}
```

In order to be valid, a vehicle data record must be formatted according to this data structure and contain all following values, expressed in the right measurement unit. The full list of fields, types and range, taken point by point from D.3.1.2 [1], is summarized in the following tables.

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
no2_1_ppb	82	signed Real	0.0 … 100000.0	Measured NO_2 concentration [ppb], values rounded to 1 ppb, for tests also resolution 0.1 ppb possible. The variable names remain unchanged (for saving effort) but the values transmitted are in µg/m^3. In the Supervisor Centre database the values are corrected starting 2014-06.
no2_1_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
no2_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 1: Vehicle data source data types (no2_1: output of the Alphasense sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
no2_2_ppb	84	signed Real	0.0 … 100000.0	Measured NO_2 concentration [ppb], values rounded to 1 ppb, for tests also resolution 0.1 ppb possible
no2_2_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
no2_2_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 2: Vehicle data source data types (no2_2: output of the e2v sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
o3_1_ppb	75	signed Real	0.0 … 100000.0	Measured O_3 concentration [ppb], values rounded to 1 ppb, for tests also resolution 0.1 ppb possible

o3_1_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
o3_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 3: Vehicle data source data types (o3_1: output of a O_3 sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
co_1_ppm	75	signed Real	0.0 … 100000.0	Measured CO concentration [ppm], for tests also resolution 0.1 ppm possible
co_1_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
co_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 4: Vehicle data source data types (co_1: output of the e2v sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
res_1_a	84	signed Real	0.0 … 100000.0	Measured of a first future additional sensor
res_1_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
res_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 5: Vehicle data source data types (res_1: output of first future additional sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
res_2_a	84	signed Real	0.0 … 100000.0	Measured of a second future additional sensor
res_2_runtime_s	8569	unsigned Integer	32 bit	Time since last power-on of sensor [s] , zero means runtime unknown
res_2_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 6: Vehicle data source data types (res_2: output of future additional sensor).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
temp_1_c	23.2	signed Real	-40.00 … 120.00	Air temperature [°C], values rounded to 0.1 °C, for tests

				also resolution 0.01 °C possible
temp_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 7: Vehicle data source data types (temp_1: output of the air temperature sensor near gas sensors).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
rh_1_pct	47.3	signed Real	0.00 … 100.00	Relative humidity [%], values rounded to 0.1 %, for tests also resolution 0.01 % possible
rh_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 8: Vehicle data source data types (rh_1: output of the relative humidity sensor near gas sensors).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
af_1_sccm	150	signed Real	0 … 10000	Air flow [sccm], values rounded to 1 sccm, for tests also resolution 0.1 sccm possible
af_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 9: Vehicle data source data types (af_1: output of the airflow sensor near the air pump).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
gps_1_long_deg	16.244373	signed Real	-179.999999 … 180.000000	GPS longitudinal position in degree referred to WGS84, positive values means east, negative values means west
gps_1_lat_deg	48.343838	signed Real	-90.000000 … 90.000000	GPS latitude position in degree referred to WGS84, positive values means north, negative values means south
gps_1_alt_m	125.3	signed Real	0.0 … 10000.0	GPS altitude [m]
gps_1_speed_mps	36.2	unsigned Real	0.0 100.0	GPS horizontal speed [m/s]
gps_1_hdg_deg	184.70	unsigned Real	0.0 359.99	GPS heading [degree]
gps_1_sat_nr	7	unsigned Integer	1 … 12	Number of used GPS satellites
gps_1_pdop_n	1.8	unsigned		GPS Position Dilution of

r		Real		Precision
gps_1_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 10: Vehicle data source data types (gps_1: output of the GPS sensor in the telematic unit).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
id_vehicle_nr	50	unsigned Integer	1 … 1000000	Vehicle ID, zero means ID unknown
id_system_nr	4	unsigned Integer	1 … 1000	Mobile System ID, zero means ID unknown
id_driver_nr	69	unsigned Integer	1 … 1000000	Driver ID, zero means ID unknown
id_version_char	1.45.03	Text	Up to 8 characters	SW Version, zero means “version unknown"
id_runtime_s	2598000	unsigned Interger	32 bit	Time since last power-on of telematics system [s] , zero means runtime unknown
id_status_char	run	Text	Up to 50 characters	Status of the system

Table 11: Vehicle data source data types (system_id: id of the mobile system).

Field	Example	Type	Range	Comment
ts_ms	1378115114000	unsigned Integer	64 bit	Timestamp [ms]
can_speed_mps	25.36	signed Real	0.00 … 100.00	Master vehicle speed from CAN-bus [m/s]
can_acc_long_mps2	2.45	signed Real	-20.00 … 20.00	Longitudinal acceleration from the CAN-bus [m/s^2]
can_acc_lat_mps2	0.78	signed Real	-20.00 … 20.00	Lateral acceleration from the CAN-bus [m/s^2]
can_acc_long_mean_mps2	2.45	signed Real	-20.00 … 20.00	Medium of longitudinal acceleration from the CAN-bus [m/s^2]
can_acc_lat_mean_mps2	0.78	signed Real	-20.00 … 20.00	Medium of lateral acceleration from the CAN-bus [m/s^2]
can_acc_long_var_m2ps4	2.45	unsigned Real	0.00 … 20.00	Variance of longitudinal acceleration from the CAN-bus [m^2/s^4]
can_acc_lat_var_m2ps4	0.78	unsigned Real	0.00 … 20.00	Variance of lateral acceleration from the CAN-bus [m^2/s^4]
can_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 12: Vehicle data source data types (can_1: received can data).

Field	Example	Type	Range	Comment
ts_ms	137811511400	unsigned	64 bit	Timestamp [ms]

	0	Integer		
imu_speed_mps	25.36	signed Real	0.00 … 100.00	Speed calculated from IMU [m/s]
imu_acc_long_mps2	2.45	signed Real	-20.00 … 20.00	Longitudinal acceleration from IMU [m/s^2]
imu_acc_lat_mps2	0.78	signed Real	-20.00 … 20.00	Lateral acceleration from IMU [m/s^2]
imu_acc_long_mean_mps2	2.45	signed Real	-20.00 … 20.00	Medium of longitudinal acceleration from IMU [m/s^2]
imu_acc_lat_mean_mps2	0.78	signed Real	-20.00 … 20.00	Medium of lateral acceleration from IMU [m/s^2]
imu_acc_long_var_m2ps4	2.45	unsigned Real	0.00 … 20.00	Variance of longitudinal acceleration from IMU [m^2/s^4]
imu_acc_lat_var_m2ps4	0.78	unsigned Real	0.00 … 20.00	Variance of lateral acceleration from IMU [m^2/s^4]
imu_valid_b	1	Boolean	0, 1	1.. data valid 0.. data not valid

Table 13: Vehicle data source data types (imu_1: received data from Inertial Measurement Unit).

2.2 Interface with urban buses

The retrieval of the real-time information related to the urban public transportation service of SASA is carried out by taking advantage of the open data API put at disposal by this operator. Data are released under the **CC-3.0-BY-SA** licence.

Real-time public transportation data is the only one dataset managed by INTEGREEN in which no data storage is made in its database (last data values are stored at this level, but only temporary without creating a historical dataset). This is mainly because at present there is no added value to maintain the history of such dataset, since it is mainly used only in order to provide the BZBus application service [2]. On the other side, the cost for storing all this huge amount of data is not negligible. Therefore, in some way it is possible to state that this is the only case in which the INTEGREEN architecture, as conceived during its definition [3], has been completely broken.

The vehicle data source implements the calls to the webservices that are now much more consolidated with respect to was originally defined during the specification process. The full specification of the present web-services is available on http://sasabus.org, the website on top of which is building its community of developers. The webservices make available the following data, according to the **VDV standard data format** [4] - [5]:

- **planned data;**
- **real-time positions;**
- **real-time stationboard informations;**
- **latest service related news;**

- **routing engine**.

At present, the vehicle data source automatically retrieves the planned data (in order to have the full reference of buses, lines and bus stops), the real-time positions and the stationboard informations. These information are directly associated to buses and bus stops, respectively.

The **real-time positions** are available under the URL http://realtime.opensasa.info. The requests to the responses are formatted in GeoJSON, as already indicated in the specification phase. The web-service allows a third-party system to make different type of requests. For example:

- http://realtime.opensasa.info/positions?lines=4:1 returns all vehicles that are presently on line number 4 and variant 1;

- http://realtime.opensasa.info/positions?lines=1:3,211:2,3:1 returns a list of lines;

In this application, the following method is used:

- http://realtime.opensasa.info/positions which delivers the full set of buses' position.

The JSON output is something like that:


```
{"type":"FeatureCollection","features":[

    {"type":"Feature","geometry":{"type":"Point","coordinates":[678534.8054976,5149293.3001406]},"properties":{"frt_fid":2377,"gps_date":"2015-05-23 14:44:58+02","delay_sec":66,"li_nr":1102,"str_li_var":"2","lidname":"10B","insert_date":"2015-05-23 14:11:56","li_r":218,"li_g":37,"li_b":29,"ort_nr":5186,"onr_typ_nr":1,"ort_name":"Fiera - Messe","ort_ref_ort_name":"(Bolzano) Fiera - (Bozen) Messe","hexcolor":"#da251d","hexcolor2":"DA251D"}},

    {"type":"Feature","geometry":{"type":"Point","coordinates":[677440.7373962,5152363.0841401]},"properties":{"frt_fid":2379,"gps_date":"2015-05-23 14:43:04+02","delay_sec":0,"li_nr":1102,"str_li_var":"2","lidname":"10B","insert_date":"2015-05-23 14:41:59","li_r":218,"li_g":37,"li_b":29,"ort_nr":5159,"onr_typ_nr":1,"ort_name":"Bivio Poligono - Abzw. Schie\u00dfstand","ort_ref_ort_name":"(Bolzano) Bivio Poligono - (Bozen) Abzw.","hexcolor":"#da251d","hexcolor2":"DA251D"}},

    {"type":"Feature","geometry":{"type":"Point","coordinates":[677190.69452764,5152145.3372987]},"properties":{"frt_fid":2389,"gps_date":"2015-05-23 14:41:48+02","delay_sec":58,"li_nr":1102,"str_li_var":"2
```

","lidname":"10B","insert_date":"2015-05-23 13:51:31","li_r":218,"li_g":37,"li_b":29,"ort_nr":5155,"onr_typ_nr":1,"ort_name":"Ospedale - Krankenhaus","ort_ref_ort_name":"(Bolzano) Ospedale - (Bozen) Krankenhaus","hexcolor":"#da251d","hexcolor2":"DA251D"}},

...

]}

The **real-time stationboard** information is available under the URL http://stationboard.opensasa.info. This webservice has one required parameter, namely ORT_NR. This represents the number of the bus stop, and has to be extracted from the webservice of the planned VDV-data. The web-service provides to a request, such as:

http://stationboard.opensasa.info/?ORT_NR=5324 all departures from the station number indicated (in the example 5324) from the requested instant until the end of the present day.

In this application, this method is called for all bus station in Bolzano, so that this information can be associated to the each bus stop.

The vehicle front-end requests all this information every few seconds, parses all this information according to the different data types available and forwards the most relevant information to the end-users application (BZBus), which are graphically presented on a map according to a proper graphical user interface.

Conclusions

The report has presented the final implementation status of the **vehicle data source** (previously indicated in the proposal as vehicle-to-centre front-end) of the Supervisor Centre.

The prototype of this component has the capability to properly receive not only the data measured by the **mobile system prototype** of INTEGREEN, according to the data dictionary defined in D.3.1.2, but is also in the condition to continuously check the real-time information of the **urban public transport operator**, SASA.

In the first case, the data source is in charge to properly validate the data package trasnsmitted (both as JSON formatting as well as type of data expected) and to forward it to the Data Center Collector according to the shared XML-RPC language [6].

In the second case, the data source parses all the data, saves is it locally and puts it at disposal to the end-user application BZBus. Data are not stored in the INTEGREEN database through the Data Center Collector, since at present there is no significant added value for doing this operation while the cost for the storage of such a huge amount of data would be non-negligible.

Bibliography

[1] INTEGREEN consortium, "D.3.1.2 "Vehicle-to-centre front-end and web interfaces design"," 2014.

[2] INTEGREEN consortium, "P.4.1.5 "Public web interface prototype"," 2014.

[3] INTEGREEN consortium, "D.2.1.1 "Supervisor Centre components requirements"," 2012.

[4] IVU Traffic Technologies AG, "Schnittstelle VDV+ Datenexport IVU.plan an RBL/BMS," 2009. [Online]. Available: http://open.sasabz.it/files/VDV_0105.pdf.

[5] VDV (Verband Deutscher Verkehrsunternehmen), "VDV 453 "Actual Data Interface - dynamic schedule synchronisation - dynamic passenger information - visualisation - general - information service - Version 2.3.2"," 2013.

[6] INTEGREEN consortium, "P.4.1.1 "Data management unit prototype"," 2014.