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Deliverable due date: M24 – November 2018

D3.6 Open data and open APIs generated in the project

WP3, Task 3.5, SubTask 3.5.4

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D3.6 Open Data and Open API
Diss. Level	PU
Status	☐ Working ☐ Verified by other WPs ■ Final version
Due date	30/11/2018
Work Package	WP3
Lead beneficiary	TSY
Contributing beneficiary(ies)	HAM, CAR
Task description	APIs development to link the domains. Access to a central user management, central ePayment Open APIs and functionalities for downloading, viewing, processing and meta information of data that will be extended in the project. The extended Urban Platform will provide Open APIs for sensor data acquisition and for searching and accessing open data. Access to spatial data will be granted, with a big spatial data hub and a client technique for viewing and re-using spatial data implementing up-to-date web technology.

Date	Version	Author	Comment
11/11/2018	0.1	Michael Fischer (HAM)	Initiating Draft
23/11/2018	0.2	Michael Fischer (HAM)	Section 2
23/11/2018	0.3	Michael Fischer (HAM)	Section 1, 3, 4
25/11/2018	0.4	Joachim Schonowski (TSY)	Section 2.1.3
28/11/2018	1.0	Michael Fischer (HAM)	Finalization
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30/11/2018	1.2	Michael Fischer (HAM)	Revisions integrated
26/11/2019	1.3	Michael Fischer (HAM)	Updated informations on open standardized API and open data sets

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Abbreviations and Acronyms

Acronym	Description
AE	Application Entity (oneM2M)
API	Application Programming Interface, a set commands, functions, protocols and objects that programmers can use to create software or interact with an external system
CSE	Common Service Entity (oneM2M)
GML	Geographic Markup Language
HTTP	Hypertext Transfer Protocol
JSON	JavaScript Object Notation
MQTT	Message Queue Telemetric Transport
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy, EU H2020 Smart City Lighthouse project (Nantes, Helsinki, Hamburg)
oneM2m	One Machine to Machine Standard body
OGC	Open Geospatial Consortium
STA	SensorThings API
WFS	Web Feature Service
XML	Extensible Markup Language

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0. Executive Summary

This deliverable describes the role of open standardized APIs and open data in relation of their usage and meaning for an Open Urban Data Platform as described by the EIP-SCC and in deliverable D2.16. It highlights the improvement of the current data and the APIs of the Urban Platform of the city of Hamburg. Due to the central role of ICT to deliver a “Smart City”, it is important for cities to develop besides traditional urban planning / development forecasts and strategies, in future also a digital strategy. Regarding the digital strategy, it is important for cities to establish a holistic and future proof view regarding the underlying, required base technologies. The core idea of such a digital smart city is to enable cross-domain data usage and exchange. Hence a central instance like an Urban Platform is required, which puts a horizontal IT layer across the different domain IT systems, e.g. smart streetlights or energy management within a neighbourhood or community.

Based on this digital strategy, this deliverable proposes a combination of OGC standards for spatial data, Sensor data (SensorThingsAPI data model) and oneM2M approach as solution for linking domains in order to provide a holistic and transparent mechanism to share open data and APIs. Across the document, main examples will show a proof about the usage of these open data-sets and APIs, while further open data-sets beyond the mySMARTLife project will be made available in the future following the developed integration workflow.

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1. Introduction

1.1 Purpose and target group

Deliverable 3.6: Open data and open APIs generated in the project is the result of the sub-task 3.5.4 related to the APIs development to link different domains within the mySMARTLife Hamburg urban platform. In this sense, this document provides an overview on the necessity of open standardized APIs within an Urban Data Platform to fully unlock its potential, in particular the possibilities of IoT in a smart city. The methods illustrated here are not restricted in demonstration cases only, but naturally those are the main focus.

To avoid a so-called vendor lock-in, mySMARTLife follows the strategy to focus on the development of an open urban STANDARDIZED platform (OUSP). In this specific case this means the usage of an existing (mostly) OGC/ISO (global standard) based urban platform of the City of Hamburg and an oneM2M (global standard) based urban platform of Deutsche Telekom AG. Both systems comply with the idea of an OUSP, were each has its advantages and the combination could take the best of the two “worlds”. The OGC is strong offering an almost complete set of standards for different purposes for an open standardized urban platform. These standards apply i.e. for meta data (CSW), static data sets (WMS, WFS-T, WCS), web processing services (WPS) and since recently also for sensor data management including the spatial relation (SensorThingsAPI). However, the standard does not cover the very southern part in an IoT world, where device provisioning and IoT harmonization are needed. Here the oneM2M standard focuses on the technical harmonization and orchestration of different domains, including aspects like device management or access management. The innovative challenge is to combine these two in order to provide the requested interoperable and future proof solution. Both systems combined provide the requested open APIs and standards from the IoT device level up to the application layer and can deliver open data based on each ontology.

The ultimate goal of the document is to show a proof about the integration of data in different domains (e.g. spatial data, electric vehicle charging points and energy data of public buildings) within the Hamburg urban platform so that open data-sets and APIs would be made available for its usage. In this way, this deliverable aims to provide information to final consumers of data (e.g. third parties to develop new services based on the APIs, citizens to access open data portal, urban planners…) about how data flows are capable of providing data accessibility and interoperability.

In order to cover the aforementioned objectives, the deliverable is distributed in three main sections:

- Overview of the open data and APIs standardized approaches that are included into the Hamburg Open Urban Data Platform with the aim of combining domains to provide a holistic procedure to consume data. As well, this section explains the OGC-SensorThingsAPI-oneM2M combined architecture as Hamburg urban platform solution.

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- Proof of usability of the open APIs through examples of new services based on EV charging stations, consuming data through the APIs.
- Integration of new upcoming services during the development of the Hamburg urban platform planned until M36 and afterwards by third parties.

1.2 Contributions of partners

Table 1 depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
T-Labs (TSY)	Sections1, 2, 3 and 5
HAM	Sections 1, 2, 3, 4, and 5
CAR	Final review and minor modifications

1.3 Relation to other activities in the project

Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D2.16	This deliverable provides the overall description of the Open Specifications Framework followed in the Hamburg Urban Platform developments.
D2.17	This deliverable provides the overall description of the interoperability through standardized data models and open APIs.
D3.1	Baseline report of the Hamburg city and data availability.
D3.5	Implementation of the extensions of the Hamburg urban platform.
D5.1	Definition of KPIs, which will be published as open data.
D5.2	Definition of data-set requirements.
D5.3	Monitoring programme and IoT data to be integrated and published.

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2. Open standardized APIs and Open Data

The unambiguous trend towards the establishment of new forms of open administrative transactions and the provision of free administrative data as "open data" was manifested on June 13, 2012 with the unanimous decision of all parties represented in the “Hamburger Bürgerschaft” (Hamburg Parliament) on the application for the adoption of a Hamburg Transparency Act (HmbTG). The LGV (Landesbetrieb Geoinformation und Vermessung - Geoinformation and Surveying) has taken up this trend in autumn 2011 and developed its own Open (Geo) data strategy.

In order to promote administrative transparency and economy, data-sets are being made available online ranging from education, culture, urban development and planning, environment to traffic and many more. Spatial data is provided in a reusable, manufacturer-independent format, which is suitable for automated processing. However, data-sets are protected if they interfere with other laws or interests e.g. privacy law. This means all data that is not protected as described before will be accessible as open data. The further development of the Urban Platform will follow these guidelines.

One central element of network operators like Deutsche Telekom AG is to enable services and business on top of an underlying interoperable infrastructure. To ensure interoperability usage of standards is a must, e.g. GSM standard for mobile telecommunication. This implies the same logic in the domain of the Internet of Things were Deutsche Telekom uses the oneM2M standard.

2.1 Open standardized APIs

The current implemented APIs follow an open, standardized design, in most cases provided by the OGC (i.e. WFS-T, WFS, WMS, CSW etc.), ensuring a reusable, manufacturer-independent format (see also D2.17). These standardized APIs are based on REST, SOAP, XML, and JSON using HTTP and MQTT. This allows data consumers for an easy integration of the open data into their systems and applications. The Urban Platform uses standard WebGIS Server Software to fulfil these requirements. The Urban Platform also focus on open standardized (ISO, OGC) APIs, which requires a full and open documentation of them. In example, the SensorThingsAPI is introduced now, being the first and only standardized API for IoT data management with spatial relation including the possibility of ontology and semantics integration.

Open standardized APIs of the Urban Data Platform are used for services to allow the possibility for downloading open data in a standardized way.

2.1.1 WFS 3.0

Originating from the spatial data infrastructure (SDI), the existing APIs of the Urban Data Platform of the city of Hamburg rely on standards that have been established in the domain of spatial information. The most relevant standardization body in this field is the Open Geospatial Consortium (OGC), which gathers businesses, government bodies and academia together to advance interoperability of spatial information.

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OGC works closely together with the International Standardization Organization (ISO), many OGC standards have been taken up by ISO.

The APIs based on OGC and ISO standards, mainly Web Map Service 1.3.0 (WMS) and Web Feature Service 2.0.0 (WFS) have proven robust and are widely integrated in many eGovernment applications. However, it cannot be denied that their architectural style (e.g. XML-RPC using HTTP as a tunnel) is not in line with best practices that have developed in the Web mainstream in recent years. This is among others due to the fact that these standards have been published about roughly a decade ago (WFS 2.0.0 from 2009, WMS 1.3.0 from 2004) and that technology has moved on.

Challenging this problem, OGC has committed to a Common Working Group with the World Web Consortium (W3C) under the title "Spatial Data on the Web". This Working Group has compiled a report "Spatial Data on the Web - Best Practices"[1], which applies current technological mainstream developed in the Web community to the field of Spatial Data on the Web. It proposes “[…] a significant change of emphasis from traditional Spatial Data Infrastructures […] by adopting an approach based on general Web standards”.

Based on these Best Practices, OGC has started work on the next major revision of the Web Feature Service specification, i.e. WFS 3.0. A draft and several implementations are available since early 2018.

The WFS 3.0 draft has been reviewed for the Hamburg Urban Data Platform within the Hamburg ICT group of mySMARTLife. A test instance of the Open Source implementation ldproxy[2] has been made available for Hackathons and internal testing purposes (see example for electric vehicle charging station in Figure 1). With its true RESTful approach, taking up Linked Data concepts and the idea of a standardised API description leveraging OpenAPI, WFS 3.0 is very promising for the purpose of making data available through state of the art APIs. It will be further evaluated and most probably be put to production on the Hamburg Urban Data platform once the specification is finalised.

[1] https://www.w3.org/TR/sdw-bp/

[2] https://github.com/interactive-instruments/ldproxy

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Figure 1: HTML representation of an electric vehicle charging station from a WFS 3.0 instance. Note that other representations (JSON, GML) of that feature are available.

2.1.2 SensorThingsAPI

Since the possibility for downloading or subscribing to open data does not only apply for static spatial data, there is a need for an open standardized API for real time spatial data. It has been decided together with Nantes and Helsinki to implement the OGC SensorThingsAPI for this purpose. This will allow an easy management of sensor data while, at the same time, allowing a standardized way of providing real time spatial data on the web using best practices from the web development community and the W3C (JSON-based, HTTP/REST, MQTT). It has to be emphasized that the Hamburg Urban Data Platform decided on a standardized API instead of developing an additional new one among the countless proprietary and not standardized APIs leading to another dead end or at least leaving a new challenge for connecting the system to other systems.

The SensorThings API (STA) applies, on the one hand, the possibility to store historic sensor data while, at the same time, providing state of the art IoT techniques such as publish-subscribe mechanisms (MQTT) to provide real time capabilities to the Urban Data Platform. The STA relies on a data model consisting of 8 entities (Figure 2). Thus, it is easily adoptable and experiences an exponential growth in its usage across the sensor community (i.e. in other H2020 projects, such as MONICA, RUGGEDIZED and many more). One of the most advantages of the STA is the very small payload for sensor results. Since it has not to send all meta data for a thing and its connected sensors. In comparison to other (mostly industrial) approaches where the complete data set is sent redundantly with every event this solution is by far more suitable for the IoT world where bandwidth at power consumption is limited and always being an issue. A more detailed description of the STA can be found at: http://docs.opengeospatial.org/is/15-078r6/15-078r6.html.

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By using this API the Hamburg Urban Platform is now extended with an Open standardized API for sensor data acquisition and for searching and accessing open sensor data.

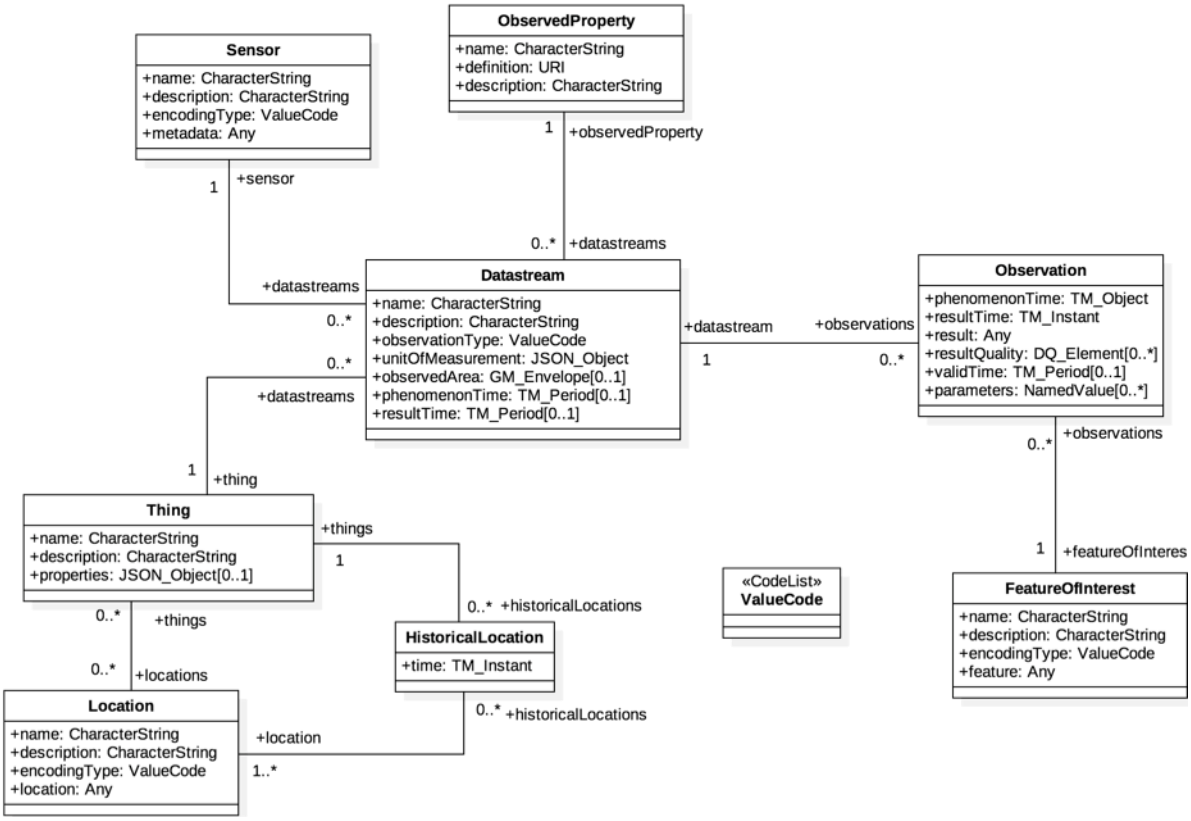

Figure 2: Data model of the SensorThings API

2.1.3 oneM2M

Based on the massive development and progress of the Internet of Things (IoT) in conjunction to Industry 4.0, and other international Industry activities, there was a pressing demand for an IoT standard. Due to the early involvement of Deutsche Telekom (DT) in Industry 4.0, DT relied and supported oneM2M very early. "The purpose and goal of oneM2M is to develop technical specifications which address the need for a common M2M Service Layer that can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide. A critical objective of oneM2M is to attract and actively involve organizations from M2M-related business domains such as: telematics and intelligent transportation, healthcare, utilities, industrial automation, smart homes, etc."[3]. Due to the strength of harmonization and orchestration of various IoT domains and thus enabling interoperability

[3] http://onem2m.org/cache/mod_roksprocet/1fdfd821aa

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across these various domains, oneM2M moves logically towards a digitized “Smart” city as illustrated in Figure 3[4].

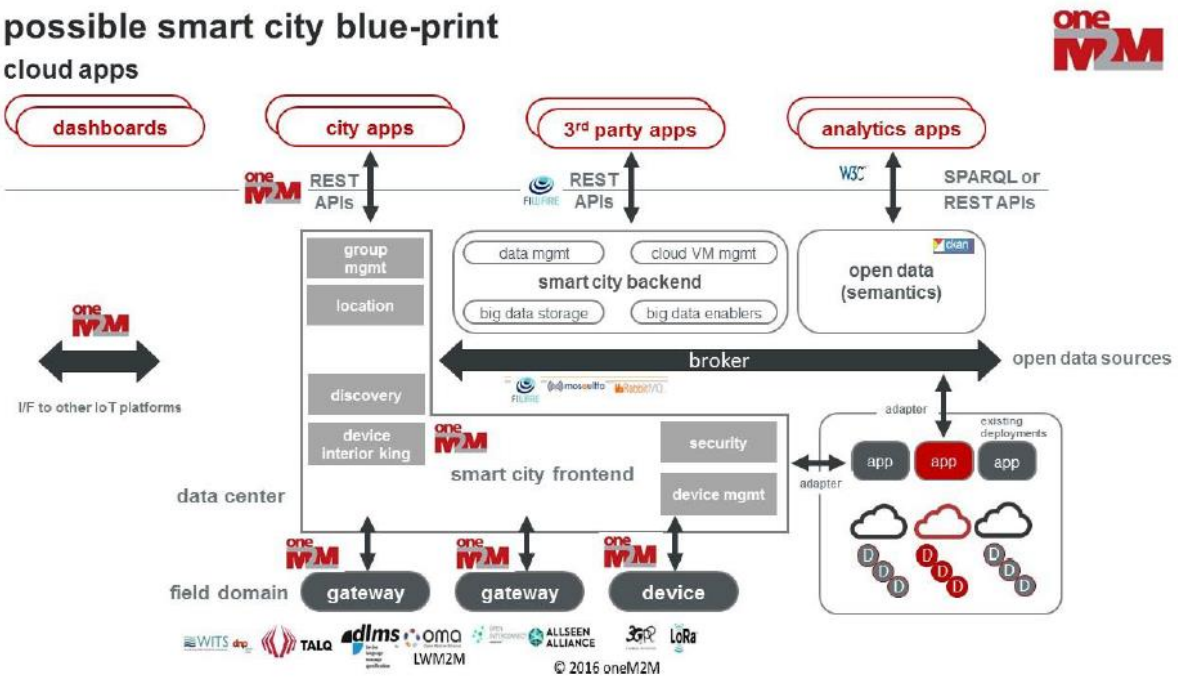

Figure 3: oneM2M smart city architecture

This oneM2M framework is based on open APIs. The central logic of oneM2M is based on the Common Service Entity (CSE), which is acting as central orchestration instance. The CSE receives data from different domains or sensors via Application Entities (AE) or Interworking Proxies. These data can be accessed from applications or they are distributed to interested parties by the CSE through sophisticated publish / subscribe mechanisms. OneM2M also provides integration with different authentication mechanisms and has an own access policy mechanism and description. This way it is possible to describe fine-grained authorization schemes for sensor data access. OneM2M provides an extensive framework for gathering, routing and orchestrating data.

Beside data-routing oneM2M covers also areas like network control functions and device management.

OneM2M started also to work on data harmonization based on SAREF ontologies. There are also initiatives to define so called device classes. This are data structures the define domain specific data semantics. Nevertheless, this work is in a rather early stage and currently there is no alignment with so SI or ISO standards

[4] oneM2M Whitepaper February 2017 „Smart Cities Done Smarter“

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2.1.4 Integration OGC SensorThings API ←→ oneM2M

While cities have an interest in applications and standards with i.e. geospatial background like OGC many industry players need a standard like oneM2M providing additional features like device or access management. Since both standards have their strengths, it is worth to build an integration or interworking.

While OGC and its Sensor Things API (STA) is easy to use and provides excellent semantic description through its data model, oneM2M provides access control and data routing mechanisms.

In mySMARTLife project, the conjunction between an OGC-STA-Server and an oneM2M server (a.k.a. Common Service Entity – CSE) is being implemented as interworking solution (see Figure 4). Thanks to this approach, IoT data coming from sensors, spatial data and standardized data model converge to provide a holistic and transparent solution in terms of open Data and APIs.

Architecture Overview
Interworking SensorThingsAPI – oneM2M

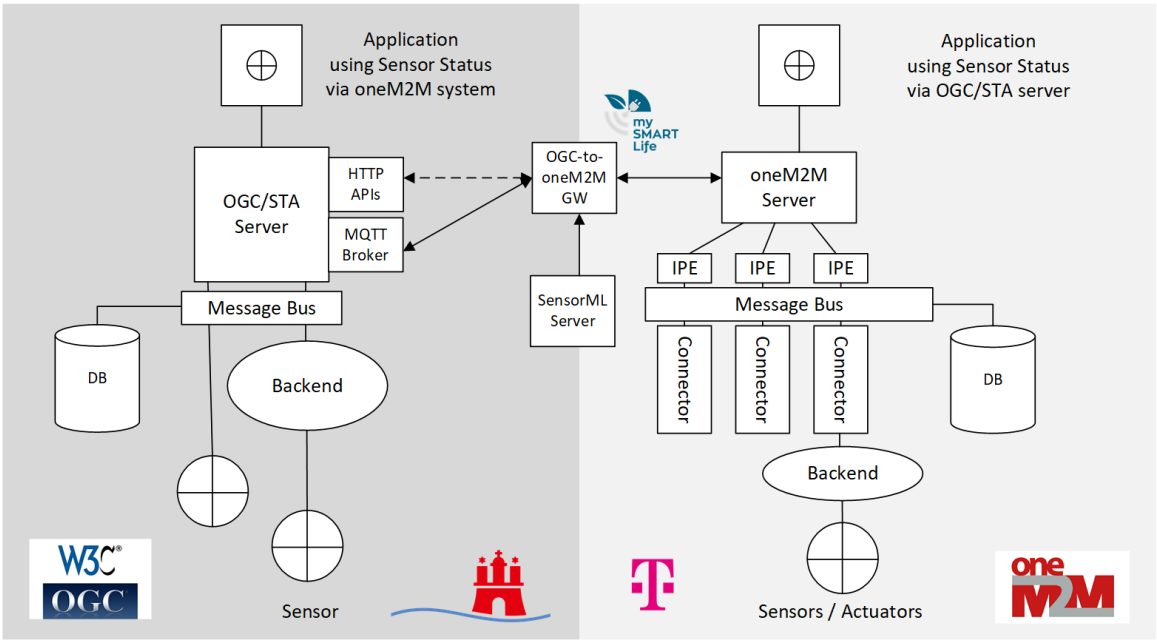

Figure 4: OGC-STA & oneM2M interwork

Considering our current combined setup, there is on the one hand side the STA server that is updated with latest data of EV charging stations in Hamburg. On the other side, there is an oneM2M – based infrastructure getting data from an energy monitoring system. The best way to demonstrate this initial interworking is to show that an application in one domain can show data from the other domain without changing its protocol. So there might be an application showing the status of the production of a photovoltaic system just by asking

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the STA server although the data are gathered from the oneM2M system. The interworking scenario has two directions (STA to oneM2M) and (oneM2M to STA).

1) STA to oneM2M

For this direction, a connector located on the oneM2M side subscribes to the MQTT broker provided by the STA server. As soon as an STA-Observation is received, it is formed in to an oneM2M request. Depending on the amount of data that is needed (e.g. location, history etc.) the connector can request additional information via HTTP interfaces from STA server and thus might enrich the oneM2M message with it.

2) oneM2M to STA

For this direction the publish / subscribe mechanism of the CSE is used. When a certain event (e.g. the latest production data of a photovoltaic power plant) is pushed to the CSE a notification is send towards the STA infrastructure.

This can be done via a proxy server. The proxy can check whether all necessary parts of the STA data model already exist and if not it can deploy them. If they already exist, the oneM2M notification event is simply formed in to the STA format and pushed as an Observation to the STA-server. One example is shown in Figure 5 where a temperature sensor data event is measuring its value in real-time, at the same time, the sensor is placed in the geospatial reference.

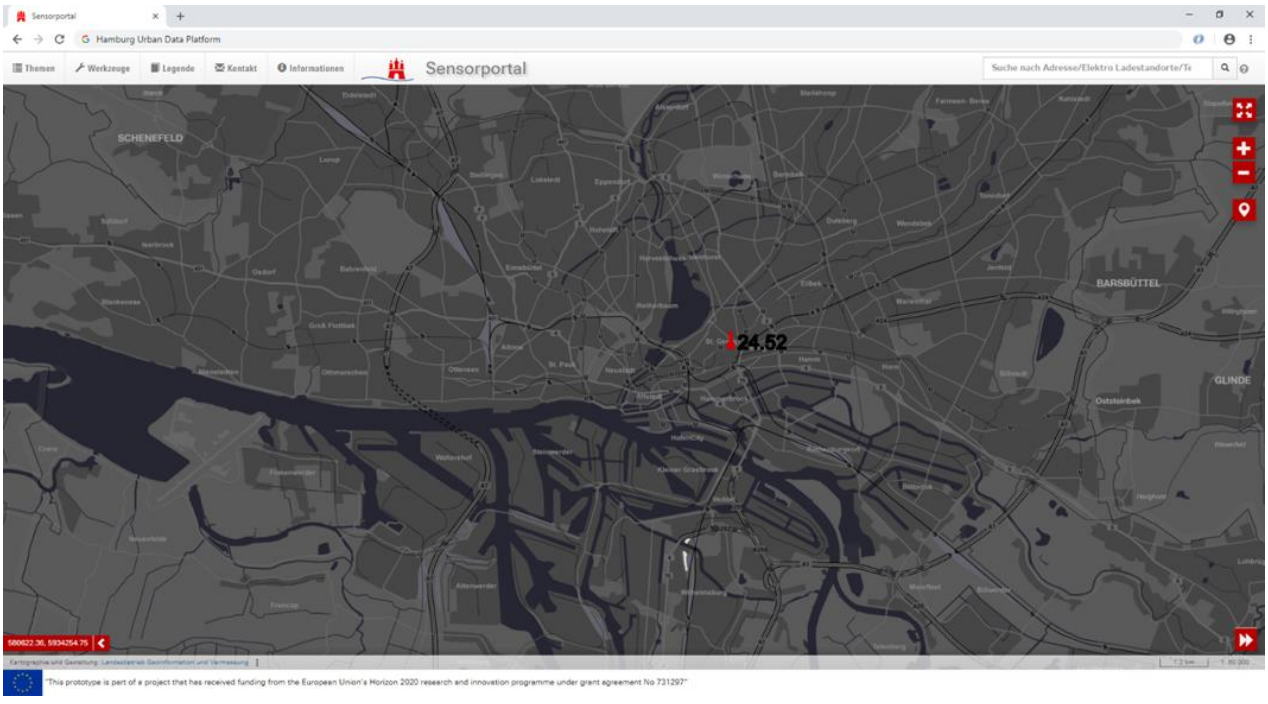

Figure 5: Hamburg Urban Data Platform providing temperature sensor data event based in real time

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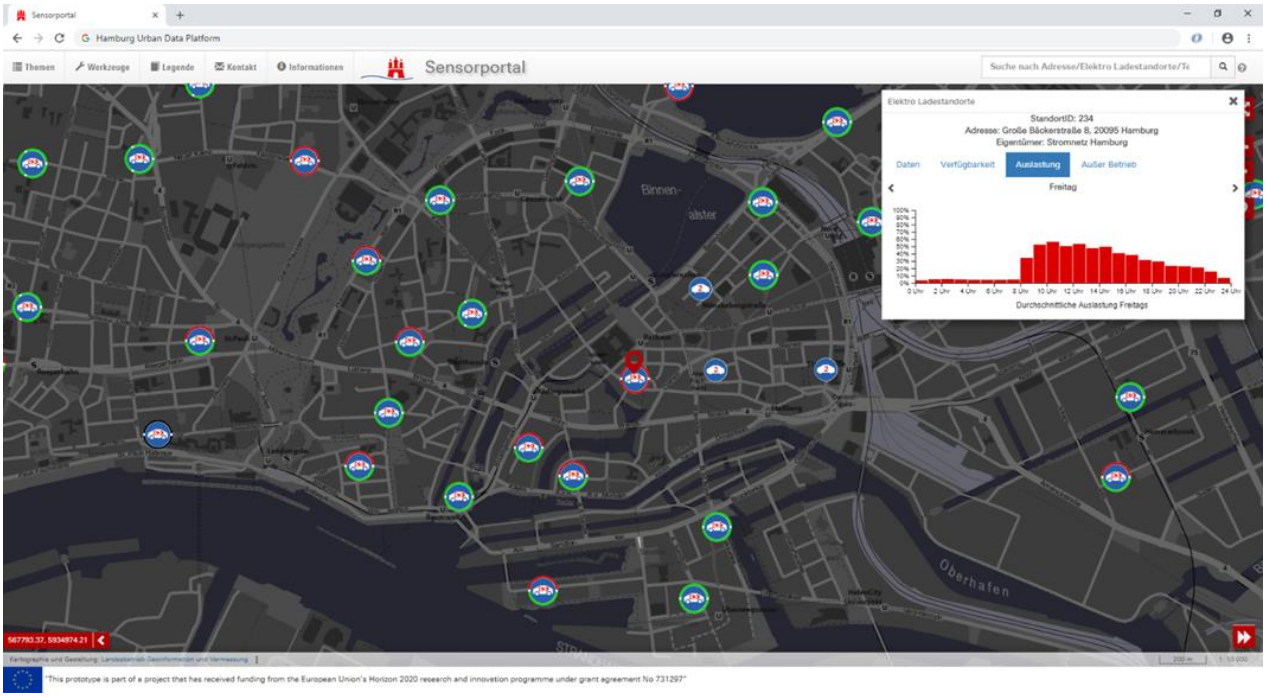

Figure 6: Real time visualization of electric charging stations including the analytics of their usage

2.2 Open Data and beyond within the project

Due to the Hamburg Transparency Act more and more data is becoming open data provided through standardized APIs. This data does not only belong to the Borough of Bergedorf, it is rather being applicable for the whole city of Hamburg. Hence, this results in a more sustainable way of the implementation and extension of the Hamburg Urban Data Platform.

Furthermore, with the integration of the real time spatial data of the electric charging station in the Urban Platform through the SensorThings API, the Open Data provisioning has been lifted to a higher level. Until recently only static data was available as a snap shot at a specific time. With the help of STA sensor data is now provided event based on real time while at the same time allowing the storage of its history. Hence, new services (i.e. Analytics of the usage of the charging stations as the example in Figure 7 and Figure 8) can now be developed based on this extension of the Urban Platform (see also section 3).

In addition, further data sources are now prepared to be incorporated in the Hamburg Urban Platform. In example the energy consumption of the buildings of Hamburg are now provided as open data. Although not exciting in the first place, the particular is the implementation of open standardized API across the whole ecosystems (see section 2.1.4). Starting from the IoT sensors themselves, through the integration layer, up to the northbound to the application layer. Up to now, cities can only rely on the proprietary APIs of different vendors for integrating sensor data in an Urban Platform, thus, leading easily to an unintentional vendor lock-in. To the best of our knowledge there is no standardized, software product independent approach for a sensor data exchange from the IoT level (including device security and provisioning) to the application

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level including all types of data in particular spatial data. However, this is not in line with the development and implementation of an Urban Data Platform according to the EIP-SCC, the findings in the ESPRESSO projects and the commitments in deliverable D2.16.

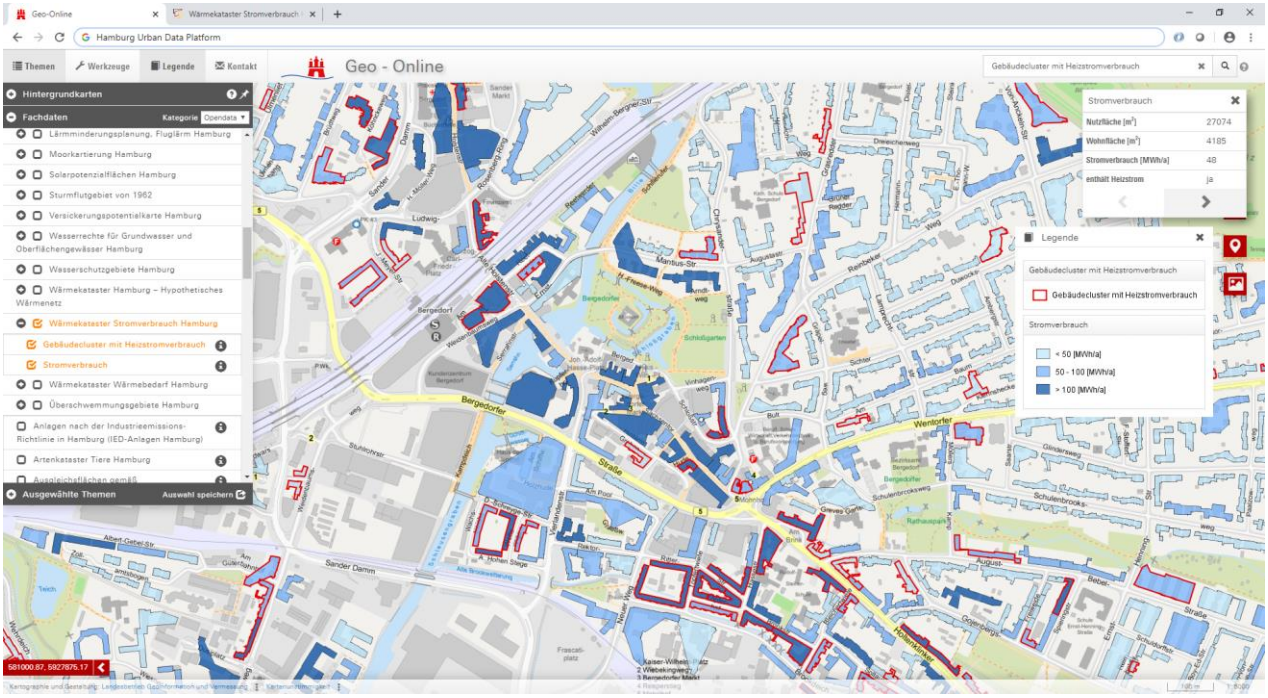

Figure 7: Aggregated energy consumption of buildingss in Hamburg

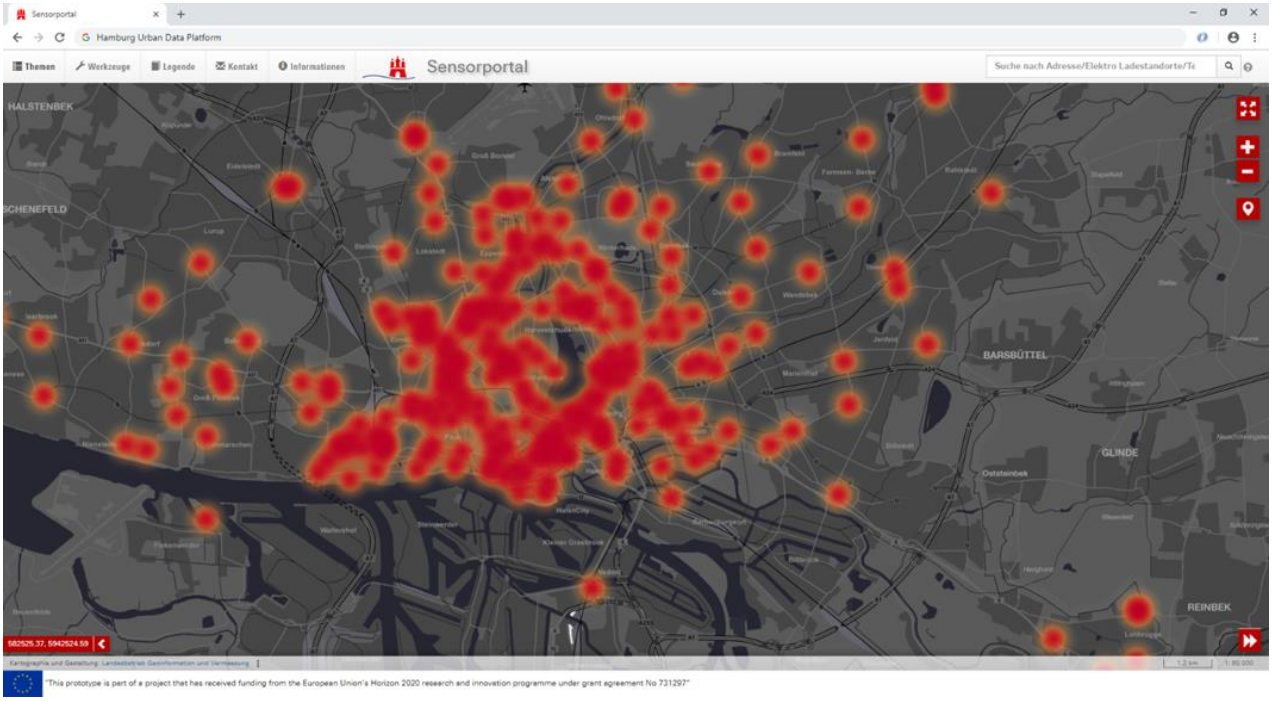

Figure 8: Real time visualization of all charging stations using a heat map

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With this new approach as described in section 2.1.4 this is not only significant for Open Data itself, it subsequently unlocks the full potential of IoT in a smart city. Anything else will lead to new (IoT) silos making it difficult to connect the data and subsequently obtain new insights for new services or decision supports. For a first proof of such an open, standardized integration the power production of the photovoltaic power plant is used. Following this domain, further domains will follow, leading to a standardized and easily replicable approach.

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3. Proof of usability of the APIs through new services

By implementing the new APIs across and within the systems, new services and applications become available. As a result the Open Source web client of the Hamburg Urban Data Platform has been extended by a real-time component and analytical features. Real-time spatial data can now be visualised with an event based approach without the necessity to reload the website (see Figure 9). This is achieved by using the SensorThingsAPI MQTT capability over websockets. In addition, since historical data is now stored, several analytical features are provided including the usage per day (see Figure 8) and the real-time spatial heat map allowing the planning agencies to easily detect the areas where charging stations are most often used and were potential new charging stations could be set up.

Based on a system of systems approach, the oneM2M system of Deutsche Telekom has realized the integration of different domains and used a partner cockpit for visualization. A high level overview of the current Deutsche Telekom system for mySMARTLife shows the connection to eight different systems (see Figure 9). The “Smart City Platform” enables for instance to switch the different lighting systems based on a specific trigger, e.g. a specific humidity value as a cross-domain use case (rainfall and dark clouds).

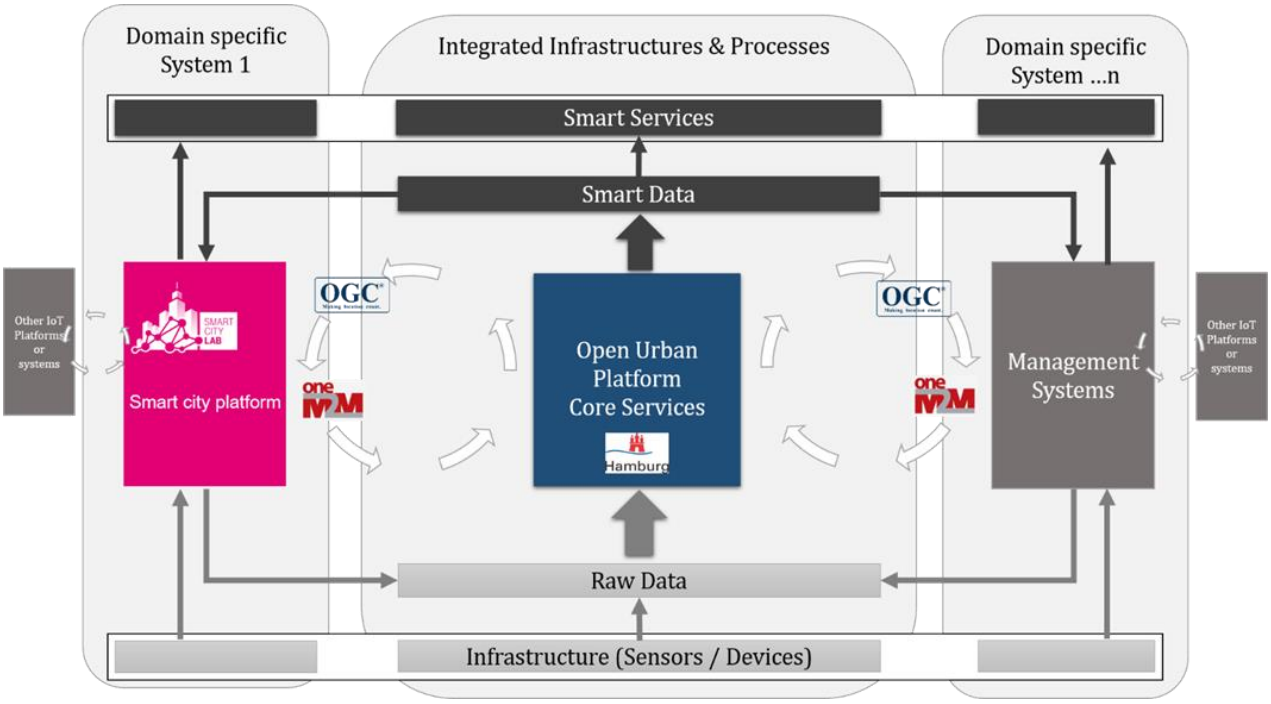

Figure 9: Open Standarized Urban Platform of Hamburg within the mySMARTLife project following a system of systems approach as proposed by the EIP SCC and DIN SPEC 91357 ensuring full interoperability by using standardized APIs and connectors from OGC and oneM2M

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The cockpit, Figure 10 and Figure 11, shows the integration of different streetlighting providers, an environmental sensor in the City of Turin (connection to an oneM2M based partner system of Telekom Italia), another non-stationary environmental sensor and shows the availability of the electrical vehicle charging stations in Hamburg based on the live data from the Hamburg system. To obtain the information between the two systems, the DTAG oneM2M system subscribes to the MQTT broker located on the STA Server of Hamburg.

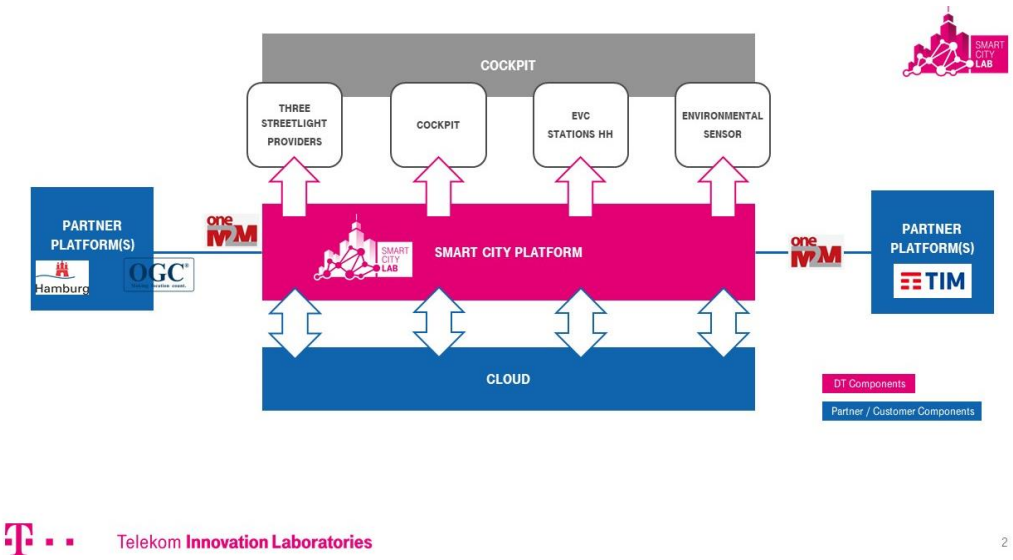

Figure 10: High level view on architecture and connected systems on DTAG System

Figure 11: Cockpit integration of various domains and connection to different urban platforms

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4. Integration of upcoming city services

The Urban Data Platform related work of the Hamburg ICT group of mySMARTLife does not take place isolated from other processes and projects in the context of the digital transformation of the city of Hamburg. In fact, it takes place in close collaboration with the relevant stakeholders in the city and is integrated with other initiatives and projects. Not an entirely new Urban Data Platform is developed in the project but the existing one is extended through mySMARTLife.

Following this approach, the sustainable use of project results after the project can be more easily realized. This also means that not all components of the Urban Data Platform have to be developed in the project itself allowing to focus on real innovation. This is the case with the access to a central user management and central ePayment services, which are already existing components in the cities' IT-infrastructure. The Urban Data platform integrates with these components. For instance, authentication and authorization for secured services (both applications and Web Services) within the Intranet is implemented using the cities' central user management (Active Directory).

The connection between the Urban Data Platform of the City of Hamburg and DTs oneM2M system should provide a powerful standardized system from the IoT level up to standardized APIs (used by third parties) fully compliant to the required avoidance of a vendor lock in and usage of global standards. Per definition this combined system will provide open APIs on all outbound system ends.

Thanks to this approach, as stated before, third party developers could implement new services as data consumers through the open APIs, citizens could access and download open data and, finally, urban planners could visualize data through dashboards to make decisions. Nevertheless, the urban platform developments are still on-going until M36 and more detailed guidance about how to consume these open APIs and open data-sets will be included in D3.5 (Design and implementation of new concepts of the Urban Platform). Moreover, the published data as open data and APIs rely on the definition of the KPIs (from D5.1 to be finished in M36, although KPIs definition is available on the interim version of M24, just the same deadline of this deliverable), requirements of data-sets (D5.2 to be finished in M36) and monitoring programme (D5.3 to be finished in M36).

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5. Conclusions

The Hamburg Urban Platform is ready to integrate new open data from the project area as i.e. already shown for the electric charging stations. As soon as upcoming (beyond mySMARTLife) data sets are available, needed data sets will then be integrated in the Urban Platform as Open Data. Due to the fact that the Urban Data Platform of Hamburg already holds a vast amount of data, the focus has been set to integrate real time spatial data (sensor data) and to follow best practices that have developed in the Web mainstream. It has become obvious that the critical issue by implementing an Urban Data Platform are standards especially when it comes to the exchange of data between systems. Those standards must be set by international standard organizations like i.e. ISO, OGC.

This way to integrate standards makes possible the interoperability, which is one of the main barriers and obstacles at time of managing data flows from heterogeneous data sources. In this sense, the work performed in this deliverable takes the lessons learnt from D2.16 about the open specifications frameworks and how to ensure data interoperability by means of using well-established and international standards worldwide, whose aim is to avoid vendor lock-in.

Finally, using the approach to merge two global and interoperable standards, OGC SensorThings API and oneM2M towards an open urban standardize platform could be currently unique. Since both systems, due to be based on global standards, guarantee interoperability and enable wide array of different domains to be connected with, this work could be a possible blueprint for other cities and communities avoiding a vendor lock-in by using a proprietary system. Since providing such a system was the basis for the Memorandum of Understanding of Open Urban Platforms in 2015 and the work of the EIP SCC action cluster on integrated infrastructure, mySMARTLife demonstrates this successfully. The current results are seen with high interests by the other lighthouse cities.

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