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Green Paper

by our member **Stefan Slembrouck**

with the topic

SMART STREET HUB:

INTEROPERABILITY TO STIMULATE MARKET DEMAND

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Digital Energy Strategies

SMARTE STADTWERKE - SMARTE KOMMUNEN

OPEN SMART STREET HUB - INTEROPERABILITY TO STIMULATE MARKET DEMAND

Stefan Slembrouck, May 29, 2020

INTRODUCTION AND SUMMARY

Europe claims to be a leader in the global development of smart cities. But also in most European smart cities, the development of a technical IoT infrastructure is still in a phase of piloting stand-alone solutions, which are often proprietary and closed.

The Smart Street is based on such an IoT infrastructure. Smart Street includes digital solutions for dynamic control of streetlighting, for parking, improving traffic flow, optimizing traffic safety and reducing air pollution, recording weather and road condition data, but also providing a public WiFi network and in the future to support connected and self-driving cars. The Smart Street is thus the digitized public space of the city, here it is decided whether the city can ensure safety, mobility, environmental and climate protection, health and quality of life. And - under the impression of the corona pandemic: here it is decided whether measures for social distancing are effective.

Intelligent street lighting is an ideal starting point for building a Smart City IoT: lamp poles and electricity are widespread, they can support the solution of local problems (darkness, light pollution, safety, vandalism ...) in the truest sense of the word. But it can also be the backbone for other Smart Street solutions that can be implemented step by step. Smart Streetlighting is visible to citizens and a flexible and perceptible reaction to their needs and emotions. There is a whole range of marketable solutions in the field of Smart Streetlighting and Smart Street, which can be integrated into streetlamps and poles and added to a Smart Street. However, they all suffer from the reluctance of the market, consisting of cities and public service providers, to invest money in large rollouts. The main reasons for this blockade are the lack of standards, the lack of multi-sourcing options and the lack of trust in the handling of data.

The European Union launched the Connecting Europe Facility (CEF) more than 10 years ago to set up appropriate processes and develop digital building blocks for European standards and barrier-free digital transport between the member states. One of the results was FIWARE ("**F**uture **I**nternet **W**are") with open source modules for IoT platforms.

This paper deals with the question of how the smart street industry can develop a standard based on FIWARE modules, which offers cities and public service companies multi-sourcing options and which increases market demand with immediate effect: the construction of an Open Smart Street Hub . It is benchmarked to the development of the FIWARE-based National 5G Energy Hub for the integration of building automation and building energy management. It ends with a sketch for a project roadmap.

1. THE MISSING OF STANDARDS BLOCKS MARKET DEMAND

In the vision of a Smart Street IoT, everything can be connected to everything. However, what we see on the market are many silo solutions and the promise that they can be connected to third-party products and services in the future (in the silent expectation that third-party providers will ultimately adapt to or even subordinate to the requirements of their own solution).

With a view to the early phase of product lifecycles, cities want to avoid IoT solutions that after some time have unrecoverable quality problems with possible impairment of connected IoT solutions. Or solutions that are not kept up to date with regard to cybersecurity, whose providers face economic difficulties, are no longer offered at competitive prices, or no longer guarantee the data sovereignty of cities.

In response, a growing number of European countries and cities are demanding open source solutions and open source solutions are also required in publicly financed development projects ("public money - public code"). With the right framework, we see this as a promising approach, even more so as intermediate steps or hybrid solutions with open and private modules are not excluded (see Chapter 7).

2. FIWARE TO REMOVE THE MARKET BLOCKADE

The challenge for the Smart Streetlighting and Smart Street solutions industry is to developf enough trust among decision-makers that with smart infrastructure projects they do not place themselves in risky dependencies on individual technologies and providers.

We assume that market demand will not only get going with perfectly integrated solutions, but that it can already be stimulated by the industry's credible commitment to the interoperability of their solutions. This includes a roadmap to increase the compatibility of providers with similar solutions and references of functioning installations with multiple providers. We believe that FIWARE, with its modular system of open-source building blocks and as a normative framework, is the key to this commitment.

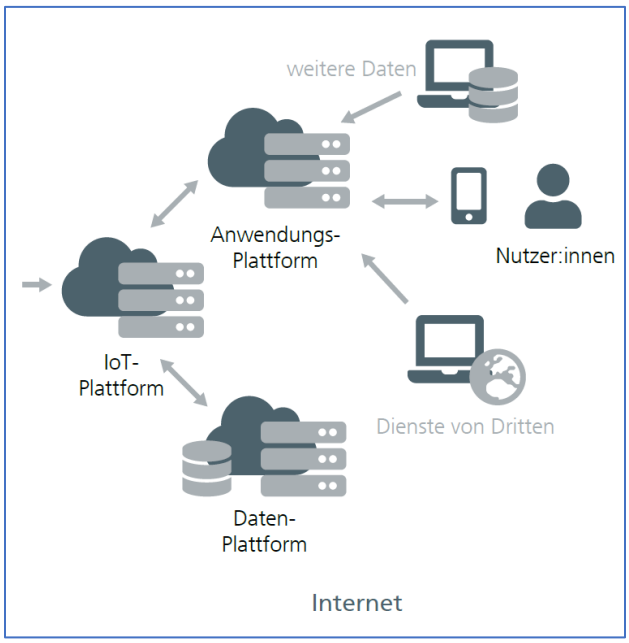
FIWARE is an initiative launched by the European Union in 2012 to remove existing technical and economic barriers that hinder the effective use of interesting data with the aim of accelerating the IoT market. This initiative is also known as the "Connecting Europe Facility Program" (CEF) and so far has delivered modules such as "eArchiving", "Big Data Test Infrastructure", "Context Broker", "eDelivery", "eID", "eInvoicing", "eSignature "," Translation "," European Blockchain Services Infrastructure "and" Once Only Principle"[1].

[1] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/Building+Blocks

We assume that intelligent infrastructure solutions should be "powered by FIWARE" or at least "FIWARE ready" as standard in order to build trust in the industry. This does not exclude that solutions without open source codes will be selected in the future, but these must guarantee sufficient openness and transparency in other ways and will thus be measured against open source solutions. Such reasons could be that FIWARE-based open source developments are not yet mature enough, that they are supported by a too small developer community, or that the portability from solution A to solution B is manageable in terms of costs and risks. However, the benchmark will be open source!

In the next steps we will examine the “FIWARE path” towards the interoperability of smart lighting and smart street solutions.

3. CHALLENGES OF INTEROPERABILITY



Quelle: Kompetenzzentrum Öffentliche IT, Impuls zu Safety, Security und Privacy im Internet der Dinge, https://www.oeffentliche-it.de/

The figure on the left shows a typical architecture of a Smart City IoT. The digitization of a city is currently developping through a patchwork of digital solutions with a multitude of data sources, data management and application platforms as well as various integration levels. However, the city will only become intelligent if these “patches” combine with one another in a meaningful way or become interoperable.

One challenge is to develop an open architecture that enables cities and their service partners to add and replace individual modules with manageable effort while at the same time enlarging and strengthening the IoT.

Another challenge is resource-oriented: How can cities use devices that are already installed and available data in additional services and new tenders to reduce costs and ensure maintenance efficiency? How can multiple management costs be prevented for a single device or a device that is captured by multiple platforms? Because, as this figure makes it clear, an IoT data infrastructure is not activated by a single data platform, but by an integrated architecture of modules.

The third challenge lies with the providers: they need to understand their core competency, limit their offer to one or a limited number of modules and see themselves as part of an ecosystem where partnerships are the norm. Today, industry thinking still dominates in linear value chains with a static customer-supplier relationship and the competitor as an eternal enemy. The digital ecosystem makes this model dynamic: in one city, the solution in the data architecture is "below" the solution of another provider, in another city it is "above" it. Moreover, as a provider, we only strengthen our customers' trust in the IoT market if we do not talk badly about the solutions of our competitors, but on the contrary, if fwe openly appreciate their performance with all differentiation.

An interoperable Smart Street solution must be easily integrated into an architecture, similar to the illustration, in an Open Smart Street Hub. The following chapters deal with the question of how such an adaptation to the European standard FIWARE can be developed. Understanding these challenges and exchanging them intensively with customers is the first step to gain more trust in the market!

4. NATIONAL 5G ENERGY HUB – BENCHMARK OF AN INTEGRATION PLATFORM

The National 5G Energy Hub research project (https://n5geh.de) is developing an Open Source platform as a "system of systems" that enables the integration of standards at the device, data transmission, IoT management and central data management level , thus the integration of solutions for the automation of energy systems and to increase building energy efficiency. The integrated open source modules are the Orion Context Broker and the NGSI data interface from FIWARE. The platform is "empowered by FIWARE"[2].

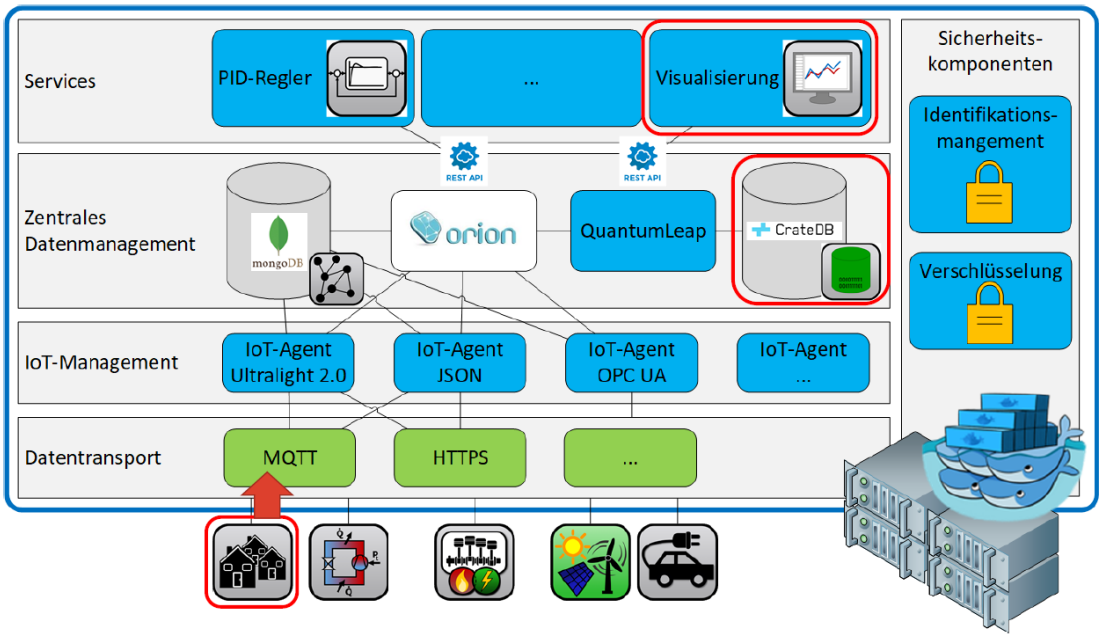


Figure: Presentation of the E.ON Energy Research Center on March 3, 2020: Integration and expansion of an existing system for the automation of energy systems

[2] https://www.fiware.org/developers/catalogue/

The following levels of interoperability can be identified from this:

- **SERVICE LEVEL - Smart City Dashboard**: Competitive silo solutions can send data to a Smart Street Dashboard via a standardized interface (e.g. NGSI from FIWARE[3]);
- **APPLICATION LEVEL, e.g. for streetlighting management**: Competitive solutions with different hardware and communication protocols can be managed via a single central data management (CMS) using the same data transmission protocol (e.g. TALQ[4]);
- **IOT MANAGEMENT LEVEL - Service-oriented architecture (SOA):** Platform architecture as the standard for platform-independent data exchange, as is already used in industrial automation processes (e.g. OPC UA[5]);
- **DATA TRANSMISSION / TRANSMISSION LEVEL** - Open message protocol: transmission of telemetric data in the form of messages between devices that enable automation (e.g. MQTT[6], HTTPS);
- **DEVICES / GATEWAY LEVEL** - **Infrastructure automation and control network**: Gateway to enable interoperability and communication with various fieldbus systems and protocols, such as those already used in intelligent buildings (e.g. BACnet[7]);
- **- FIELDBUS SYSTEMS:** Hardware components (sensor-actuator controllers) are equipped with modules that enable direct communication with other hardware components via PLC, Ethernet or mobile communication networks, as already used in IoTs from smart buildings (e.g. LONMark[8],, KNX[9]) be used.

The challenges and approaches to creating interoperability in building automation are very clearly described in a guideline, which was written jointly by the Berlin Senate Department and the Berlin University of Applied Sciences.[10]

Let's take a look at the FIWARE building blocks. What do they deliver and how can they be used to build an Open Smart Street Hub that benchmarks the development of the National 5G Energy Hub?

5. FIWARE

FIWARE is a curated framework made up of open source platform components for faster development of intelligent solutions. For this purpose, components are combined with each other, which enable the connection to the IoT with context information management and big data services in the cloud.[11] To date, around EUR 750 million have been invested in FIWARE, around 60% of which from European funds. The **FIWARE FOUNDATION** is a non-profit organization that provides resources for the implementation of the FIWARE mission by promoting, expanding, protecting and validating the FIWARE technologies and the activities of the FIWARE community. The FIWARE FOUNDATION currently has more than 300 members from over 35 countries (also outside Europe) [12].

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[3] https://fiware-datamodels.readthedocs.io/en/latest/ngsi-ld_howto/index.html
[4] https://www.talq-consortium.org/
[5] https://de.wikipedia.org/wiki/OPC_Unified_Architecture
[6] https://de.wikipedia.org/wiki/MQTT
[7] http://www.bacnet.org/
[8] https://www.lonmark.org/lon-technology/guidelines/
[9] https://www.knx.de/
[10] https://www.stadtentwicklung.berlin.de/bauen/nachhaltiges_bauen/download/gebaeudeautomation/Leitfaden_GA_Maerz_2018.pdf
[11] https://www.fiware.org/about-us/
[12] A good intro is also provided by FIWARE's paper “Expanding the Scope of CEF Digital to the Smart Energy Domain - Leveraging on the CEF Context Broker and the SAREF Ontology to implement Smart Energy use cases”, which is also discussed in this paper [cited below under "Expanding"].

Thus, we can understand FIWARE as a set of digital components on the one hand, and the vision (the normative framework) of an open data infrastructure on the other, which enables the integration of countless large and small software companies in the development of a standardized IoT landscape and supports the data sovereignty of cities and regions . In this sense, FIWARE is the framework and prerequisite for the Smart City made in Europe.

In Europe, we can now see that public tenders for solutions in the areas of smart streetlighting and smart street are increasingly demanding at least “FIWARE ready” status. [13]

5.1. CONTEXT BROKER

FIWARE itself is not a platform. It is a curated framework of open source software components that can be put together and integrated with other third-party elements to create “powered by FIWARE” platforms. In this regard, FIWARE supports the faster, easier and cheaper development of intelligent solutions[14].

The core component of every "powered by FIWARE" platform is the so-called **Context Broker**, which supports the FIWARE NGSI API, a simple but powerful API for collecting, managing and providing context information or for accessing context information. The FIWARE NGSI-API enables the integration of FIWARE platform components and ensures their interoperability and portability (replicability) for various "Powered by FIWARE" platforms.

A c**ontext broker** can collect information from other systems or contexts and convey or translate it into a higher context. It can retrieve information from the energy context (represented in an "energy ontology" such as CIM[15]), from traffic, surroundings, etc., which creates the new metacontext "street". This makes it understandable that contexts can quickly become very complex and ambivalent. We can also understand that each context needs its specific semantics, relationships, functions, taxonomies, etc. We therefore need a multitude of languages and metalanguages in order to build a system that we understand from different user perspectives and can target.

But what does context mean and why is context data or context information so important for the development of an IoT?

Data analyses, especially AI-controlled data analyses, are based on pattern recognition, taxonomy and semantic networks.

[13] Valencia: https://www.valencia.es/contratacion/xcontratacion.nsf/vLicitacionesTodas/F37450C3B0B89AC5C12581BF002C68D8/$file/PLIEGOS%20T%C3%89CNICOS.CAS_firmado.pdf
APEGR: https://www.apegr.org/images/descargas/ESMARTCITY/PliegosPILOTO_HTAJAR_eSmartCity.pdf
[14] „Expanding“, page10
[15] Common Information Model, an IEC standard developed by the electrical industry

Pattern recognition affects the simultaneous occurrence of data, instances or incidents, e.g.: A high number of vehicles on the road correlates with a high number of humans on the road.

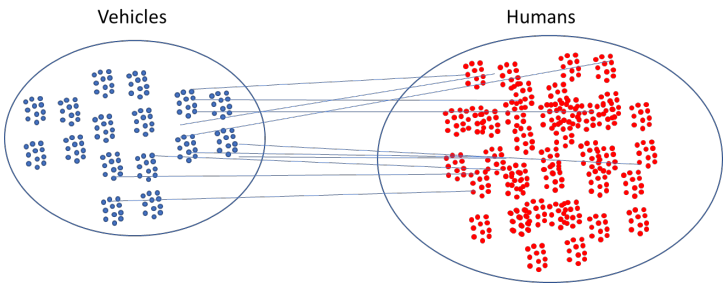

Fig .: a pattern in the form of a correlation

A **taxonomy** is e.g. a hierarchical network of concepts, example:

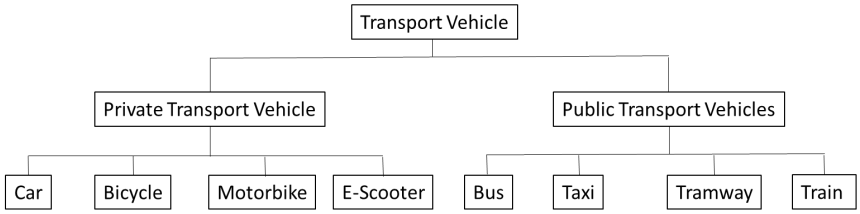

Fig.: a taxonomie

The **semantics** represent the relationships of identified objects

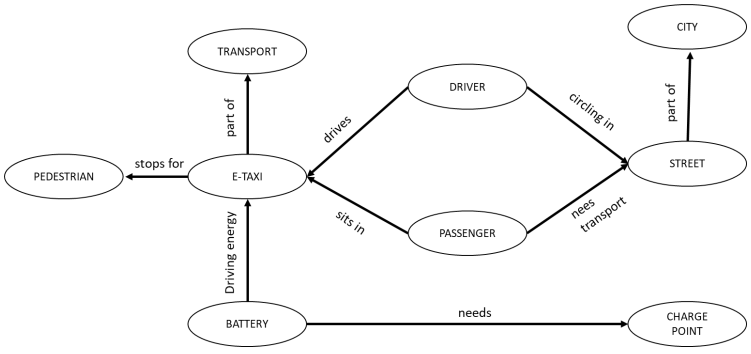

Fig.: a semantic network

Semantic networks are also called ontologies: the description of knowledge as a system of objects, relationships and instances. An instance is an object at a time in a particular situation, e.g. a 3 year old taxi with winter tires (this is the same taxi five years later in summer with summer tires). Even more interesting is the ontological perspectivism: The perspective in which I call a taxi as a passenger (User A) differs from the perspective of a taxi driver (User B) looking for a passenger or a pedestrian (User C) who is crossing a street in front of an approaching taxi. **Data become information only as part of a system, as part of a context**. A context can be a product of several other contexts, e.g. the Internet of Things (IoT) is

an accumulated system of systems or contexts in a street with energy, traffic, air, people, wild animals etc. We expect an IoT to uncover or create new relationships between things and use them to control the environment more safely and efficiently, or to improve quality of life. In an IoT, things and relationships from different sectors and domains as well as from different providers have to connect with each other.
For this reason, a context broker can provide syntax and semantics (structure and information) and open interfaces for an IoT, whereas this is not the case for a single language or a single protocol.

However, a context broker must build on a certain ontology, which determines which information from which context is relevant for which purpose: it is a **normative work** that decides between "valuable" and "not valuable" information. This means that the Internet of Things cannot be built without a specific goal, it does not just connect everything with everything, especially not automatically and without effort. One conclusion is therefore that interoperability must be developed (and tested) within the scope of a specific project with a specific business or value case.

An ontology of the context broker is SAREF - the Smart Appliances Reference (reference model for smart devices).

5.2. SAREF – SMART APPLIANCES REFERENCE

The SAREF ontology is a consensus model that facilitates the comparison of existing assets (standards / protocols / data models / etc.) in the area of smart devices. The SAREF ontology is ETSI[16] certified and offers modules that enable the separation and recombination of the different parts of the ontology depending on the requirements. It is the semantic core model for smart devices that contains the data elements that are used in more than one domain[17].

Because the data of smart devices can be used in multiple domains or originate from multiple domains, certain data elements for a specific domain may not be defined in SAREF. To process these additional data elements and to be able to provide a specific domain with a semantic model that meets all the requirements of this domain, it is possible to create extensions for SAREF[18].

For example, the energy, environment and building sectors are now part of the normative work, and **SAREF4ENER is intended to enable the (currently) lack of interoperability between proprietary solutions** developed by various consortia in the field of smart homes.

The energy domain was integrated into the context broker via a SAREF extension with the (relevant for electrical distribution networks) CIM information model and based on the standard IEC 61850 protocol.

[16] https://www.etsi.org/
[17] „Expanding“ pages 32cq.
[18] idem

5.3. NEW SAREF EXTENSIONS

SAREF can be extended to other domains, e.g. Smart Streetlighting and Smart Street. For this purpose, the requirements for a first semantic model must be investigated:

- Collecting requirements, use cases and identification of existing sources (e.g. standards, data models, ontologies, etc.) from the relevant domains to determine the requirements for an initial semantic model for each domain based on at least 2 use cases and existing data models.
- determining the creation of a SAREF extension for each of the above domains based on the requirements.
- Providing a user interface for device feedback that interprets and generates data models based on the SAREF extension for Smart Streetlighting.

The TM Forum[19] has developed a (first) data model for street lighting: **StreetlightingModel**, which is published on Github and on the FIWARE website. This model defines concepts, terms, status, etc. in the area of public lighting.

With the help of a SAREF extension, a semantic (meaningful) connection to a domain can be established.

5.4. NGSI-LD – CROSS-CUTTING CONTEXT INFORMATION MANAGEMENT

To enable (almost) real-time access to information from many different sources and to make it easier to find and exchange information with open databases, mobile apps and IoT platforms, we can build on FIWARE NGSI-LD. NGSI-LD is a version of NGSI, the Next Generation Service Interface of the FIWARE Context Broker, extended by Linked Data (LD) in cooperation with JSON-LD.

NGSI is an open programming interface that enables the **structural connection** between different software programs (cross-context).

5.5. CONCLUSIONS SAREF - NGSI

With SAREF and NGSI-LD, the Context Broker offers two powerful tools that enable software programs to connect with other software programs and extract meaningful information from them. This information can then be linked / integrated with information from other domains or applications.

The National 5G Energy Hub is ultimately the result of such an integration based on the Context Broker / SAREF / NGSI in the field of building energy. It can therefore be used as a benchmark for the development of an **open and integrated Smart Street architecture** – the Open Smart Street Hub - for the interoperability of Smart Streetlighting and Smart Street solutions.

When benchmarking the National 5G Energy Hub, we can therefore assume that by developing a SAREF extension for Smart Streetlighting and Smart Street and connecting the software via NGSI-LD to the Context Broker, an **Open Smart Street Hub** has been set up and thus the **first stage efficient interoperability** between different Smart Streetlighting and Smart Street solutions.

[19] https://www.tmforum.org/about-tm-forum/

6. OPEN SOURCE

An Open Source infrastructure guarantees maximum transparency and traceability with regard to "what happens to a city's data". It crucially supports the desired data sovereignty, which cities in turn must ensure in order to build their citizens' trust for the Smart City, or more bluntly: trust for the city of the 21st century. Open source enables a city to receive a fair share of the economic and social added value created by data-driven solutions. [20]

Open source enables cities, authorities and public companies to launch public tenders for developments and adaptations in which local software companies can also participate, thereby strengthening the local digital talent pool and of course local value creation.

Considering the total cost of ownership, open source solutions can also be significantly cheaper than proprietary solutions. The FIWARE community currently consists of around 5000 programmers worldwide. FIWARE has now entered a partnership with the Linux Foundation and together they offer a powerful global community that (more and more often) can keep up with the big technology companies.

Open Source enables the development of smart city software, which is rooted in the European value system of an open and free society with maximum respect for individual freedom and self-determination and which is attractive for many other countries outside of Europe. Open source is a normative framework that contributes significantly to the implementation of the vision of a European Smart City that is anchored in the European value system.

In Italy, the development and use of open source software is required for public service providers. In Germany, the use of open source software is a prerequisite for applications to Smart City funding projects ("public money - public code")[21]

The Context Broker is an Open Source development. This means that any qualified programmer can modify the software according to Github rules[22]. The scenario described for creating interoperability with the help of FIWARE fully supports the requirement "public money - public code".

However, the context broker can also integrate proprietary solutions. This enables users to choose their own (dynamic) balance between open source and proprietary solutions and can include investments already made via gateways or at the application level. However, the discussions about whether such a hybrid solution can guarantee the data sovereignty of a city diverge.

In this sense, the Open sees itself as an open source system that can integrate both open source and proprietary solutions.

[20] See the reasoning of the FIWARE-based open source framework Synchronicity: https://synchronicity-iot.eu/
[21] https://www.smart-cities-made-in.de/
[22] https://github.com/

7. STEPS TO BUILD AN OPEN SMART STREET HUB

A roadmap for building an Open Smart Street Hub can look like this:
(1) Project description
(2) Estimation of person-years - (FIWARE estimates that 1 person-year is required on your part)
(3) Examination of standard protocols for smart streetlighting to assess the required adjustment effort, e.g. Data models from TALQ and TM Forum
(4) budget planning
(5) Research of funding programs and possible industrial partners for co-financing
(6) Obtaining municipal partners for field trials
(7) Creation of a schedule
(8) Establishment of a project consortium and establishment of a steering committee
(9) Create and sign LOIs
(10) Submit funding applications
(11) Start the project

8. CONCLUSIONS

The initial question in this paper was: Can we quickly create enough confidence in the Smart Streetlighting and Smart Street solutions industry so that cities and municipal organizations can tender for the extensive use of these solutions?

The author is convinced that this is the case with the construction of an Open Smart Street Hub. However, we need leading smart cities in Germany in the project team or its steering committee to ensure that formulations, modules and solutions fully meet the expectations of cities and their service providers.

We do not want to fail to mention that there are also critical views about the current performance of the FIWARE modules. However, since open source does not mean “already perfect”, but “open for improvements”, we invite the community to jointly create the appropriate open source smart street framework, including improvements to the FIWARE building blocks, if necessary. We have to develop existing standards, not create new ones!

9. ACKNOWLEDGMENT

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