BIG IoT – Interconnecting IoT Platforms From Different Domains – Final Results

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***Abstract*—The Internet of Things (IoT) is today separated by different vertically oriented platforms for integration of all the different devices. Developers who aim to access other platforms and access that data are forced to manually adapt their interfaces to the specific platform API and data models. This paper highlights the work of the BIG IoT project that aims at launching an IoT marketplace and ecosystem as part of the European Platform Initiative (IoT EPI). The project finished end of 2018, so we present the setup and the final results of the integration of the use cases that have been implemented in Northern Germany, Italy and Barcelona.**

Keywords-BigIoT; Connectimg IoT; Interoperability.

I. INTRODUCTION THE PROBLEM OF MISSING IOT INTEROPERABILITY

The idea of the IoT is in widespread use since the last few years, collecting sensor data from various application domains. However, so far, these IoT platforms do not form a vibrant ecosystem. There have been lots of research and innovation projects in the context of the IoT. Nonetheless, no broadly used professional eco-systems for the IoT exist today. One reason for this is the large number of stakeholders who are involved in IoT ecosystems. Among these are providers of platforms and things, as well as application developers, and end users. Another reason for this issue are the high entry barriers for developers of services and applications. This is caused by the heterogeneity of all known IoT platforms. Developers who want to access things and additional data from different platforms need to manually access them by implementing specific adapters. Also, incentives are missing for platform providers to open their systems to third parties.

These different issues all relate to one particular challenge: the missing interoperability on the IoT. Today, various protocols and standards are available on the IoT [2]. This heterogeneity ranges from basic communication protocols such as CoAP [3] and MQTT [4], to focused standard families, such as oneM2M [5] or OGC SWE [6].

II. THE BIG IOT APPROACH

Bridging the Interoperability Gap of the IoT (BIG IoT) [6] is the project that aims at enabling the access of services and applications from multiple IoT platforms, standards and domains towards building IoT ecosystems.

Previous EC-funded projects that address such enablement of IoT ecosystems are, e.g., IoT-A, by providing a common architecture, FIWARE that offers Generic Enablers as building blocks, or projects such as compose and OpenIoT, which offer dedicated IoT platforms to aggregate other platforms and systems. BIG IoT will not develop yet another platform in order to enable cross-platform IoT applications. Instead, to reach the above outlined goal, BIG IoT builds up on 3 key pillars for an interoperable IoT ecosystem: (1) a common BIG IoT API, (2) well-defined information models, and (3) a marketplace to monetize access to resources. This approach is illustrated in Figure 1. Of central importance is the BIG IoT API, which includes functionalities such as ID management and discovery of things, access to things on platforms, tasking of things to send commands, as well as vocabulary management for handling semantics and security management. In order to interact with the marketplace, the API implemented by IoT platforms supports charging for access to things. The generic BIG IoT API as well as the underlying information models have been defined in conjunction with the Web of Things Interest Group at the W3C for standardization.

The details of this technical baseline have already been specified [8] in a comprehensive architectural design. Thereby, particular importance has been given to specific security and privacy requirements [7]. While these technical considerations build the foundation for the ecosystem to function, a crucial aspect to growing an ecosystem is the underlying business mod-el. Therefore, the BIG IoT project has analyzed various business cases and value networks [9].

 ISBN: 978-1-61208-719-1

III. USE CASES: OVERVIEW AND EXAMPLE

The BIG IoT project has developed a first prototype of an IoT ecosystem with overall 8 IoT platforms using all the common BIG IoT API. Among them are platforms from most of the partners: Bosch, CSI, Siemens, VMZ, and WorldSensing. The use cases to verify the interoperability span the mobility domain and include smart parking, bike sharing and traffic management. They are demonstrated and verified in pilots in Barcelona (Spain), Piedmont (Italy) and Berlin/Wolfsburg (NG, Northern-Germany).

The main focus is put on specifying services integrated and offered via the BIG IoT Marketplace. Additionally, applications based on the services that are show-cased are specified. The work is executed for all three pilots, taking into account the specific characteristics of the infrastructure as well as pilot-specific requirements.

The Northern Germany Pilot focuses in Berlin on the already installed network of parking sensors (Siemens) in dedicated areas as well as a variety of sensors throughout the city (VMZ).

Additionally a semi public parking area at VMZ's premises will be equipped with radar sensors to detect parking vehicles. Provided services and apps will be:

- smart parking,
- smart charging,
- public transport optimization,
- multimodal route optimization,
- parking and charging info and
- reservation of parking spots

The smart objects are charging stations, parking detectors and Wi-Fi probes as well as location sensors on buses, which deliver their data to availability services for further provision to the BIG IoT ecosystem. The data from those smart objects provided by the avail-ability services are used by other services or by the end user applications directly.

The services are

- Parking spot availability,
- Parking spot WMS,
- Parking reservation
- People density estimation on bus,
- People density estimation in area,
- Live bus location,
- Charging station availability and
- Charging station WMS.

The services support the different applications with offerings in terms of raw and aggregated data and functionalities.

We will present the first success story showing the integration of parking data from different sources (Berlin, Munich, Barcelona) via the already existing Marketplace into integrated end user applications.

IV. NORTHERN GERMANY PILOT

This BIG IoT Pilot makes use of innovative solutions already in place in the mobility innovation labs Berlin and Wolfsburg, the Northern Germany headquarter of automotive industry. The pilot shows how BIG IoT can contribute to mobility innovation in metropolitan areas, middle-sized towns and the connected com-muter traffic, addressing the future needs of urban and rural mobility. The pilots´ main target is to enable solutions for efficient parking, optimized public transport, better usage of e-mobility infrastructure and multimodal mobility information to support an efficient and sustainable mobility and a better environment. This is done by providing services and apps for

Smart Parking: Making use of on street Siemens parking radar sensors in Berlin and parking detectors in public car parks in Wolfsburg. BIG IoT provides a Smart Parking App to inform car drivers on location and availability of parking spots. Thus, car drivers find the closest parking spots and parking search traffic - a major cause for urban traffic stress - is reduced. The sensor data are provided by BIG IoT-enabled platforms such as Siemens APM (Advanced Parking Management) platform and BOSCH Bezirk platform. In addition to parking availability, reservation of parking spots will be provided as a service. Being BIG-IoTized enables Siemens Smart Parking App to consume any BIG IoT parking offerings, helps to extend the geographical coverage of parking information and increases business opportunities for service providers. Step one on the way to a European solution has al-ready been done with the integration of WorldSensing parking data of our co-pilot Barcelona – enabled by: BIG IoT.

Public Transport Optimization: Based on Wifi-sensors on connected buses Wolfsburg public transport operators get better information on bus occupancy and people waiting at bus stations. Wifi-sensor data is integrated in BIG IoT enabled BOSCH Smart City Platform. This helps to optimize vehicle usage and bus line planning to get more customer demand oriented public transport services.

E-Mobility: Where can I find the next free charging station to charge my e-car, e-scooter, e-van? By providing this crucial information to e-mobility users BIG IoT contributes to the success of e-mobility. E-Mobility in Berlin picked up speed in 2012 with first charging stations on public ground and has been continuously extended to presently more than 350 charging points. Location and status of more than 350 charging stations in Berlin are currently provided via BIG IoT enabled VMZ multimodal mobility platform. With higher numbers of e-vehicles the need to reserve a charging station will increase in the future. Thus, BIG IoT reservation service for charging stations is an appreciated Open Call contribution.

Multimodal Commuter App: This App consumes sensor and mobility data coming from various BIG IoT enabled

 ISBN: 978-1-61208-719-1

platforms to inform Commuters on the route between Berlin and Wolfsburg. The App pro-vides car and public transport routing functionalities and guides car drivers to available parking spots and charging stations, includes BIG IoT offerings for real time traffic information such as traffic detectors data, incidents and traffic messages for car and public transport. Incorporating diverse data offerings of the BIG IoT Marketplace offering collection the App bridges the interoperability gap of various platforms to provide a multi-modal real-time based information system for mobility end users.

V. RESULTS AND CONCLUSIONS

BIG IoT provides the common base for enabling different IoT platforms to access their sensors, data and services by a common BIG IoT API and the market-place behind to orchestrate exchange. The major results achieved have been:

- Subscribe to marketplace is a couple of lines of code, only
- Connect to data source is a couple of lines of code, as well

Effort for integration (as an independent docker container) of data has been reduced from days to minutes. More and more Data Sources and Services Providers joined and join allowing to choose in a rich marketplace.

Marketplace and all other source code is made avail-able open source through an eclipse license.

ACKNOWLEDGMENTS

This work is supported by the BIG IoT project that has received funding from the European Commis-sion's Horizon 2020 research and innovation program under grant agreement No 688038. This article pre-sents the current status of work in the project. We thank the consortium partners for their feedback and fruitful discussions. The work will be further evolved as part of the ongoing architecture development in the project.

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 ISBN: 978-1-61208-719-1