Business Models for Interoperable IoT Ecosystems

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Abstract. The Internet of Things (IoT) is growing and more and more devices, so-called "things", are being connected every day. IoT platforms provide access to those "things" and make them available for services and applications. Today, a broad range of such IoT platforms exist with differing functional foci, target domains, and interfaces. However, to fully exploit the economic impact of the IoT, it is essential to enable applications to interoperate with the various IoT platforms. The BIG IoT project aims at enabling this interoperability and supporting the creation of vibrant IoT ecosystems, which facilitate the development of cross-platform and cross-domain applications. While the value of interoperability for the overall economy is well understood and cannot be underestimated, some stakeholders may still need to find their business value in interoperable IoT ecosystems. Thus, this paper identifies the different stakeholders of such ecosystems, and analyzes how these stakeholders can enhance their existing business models when taking part in an interoperable IoT ecosystem.

Keywords: Internet of Things, Ecosystems, Business Models, Interoperability

1 Introduction

Since its very beginnings, the notion of the "Internet of Things" (IoT) [1], as technology that enables physical assets to become parts of information chains, has experienced an ever increasing attention. Today, the IoT has become a reality for businesses and consumers. Connected devices, or "things", are the fundament of the IoT, and they range from connected light bulbs, over personal fitness trackers, to

geolocated shipping containers. Various studies predict significant growth of the IoT and its business value in the coming years. E.g., Gartner anticipates an increase from 6 billion connected devices in 2016 to over 20 billion in 2020 [2]. A recent McKinsey analysis [3] foresees that, by 2025, IoT applications will have an economic benefit of $3.9 to $11.1 trillion; up from $0.3 – $0.9 trillion in 2015.

Those studies are encouraging, since they suggest a tremendous impact of the IoT over the coming years. Nevertheless, the McKinsey analysis [3] also points out a significant threat to the estimated economic benefit: *missing interoperability*. Specifically, the authors state that a 40% share of the estimated value directly depends on interoperability between IoT systems, i.e., it can only be achieved if two or more systems are able to work together. E.g., an adaptive traffic control system of a city has more value, the more information systems it can interact with. Only if it can interoperate with different systems, e.g., for digital traffic signage, traffic lights, parking systems, or public transport, a traffic control system can reach its full potential.

Establishing interoperability on the IoT is the vision of the BIG IoT project[1] [4]. In order to support the development of cross-platform and even cross-domain applications and the emergence of entire IoT ecosystems, BIG IoT delivers key technological enablers. First, a common API among IoT platforms is developed so that application development is facilitated. Second, a marketplace as a center piece of an IoT ecosystem is introduced and implemented. The marketplace is key for enabling all stakeholders of the ecosystem to participate in revenue streams.

However, to make such interoperable IoT ecosystems possible, the benefits for all stakeholders need to be understood and pointed out. While the value for the user (e.g., a city administration) is clear, some stakeholders have protected assets and benefitting from an interoperable ecosystem is not obvious. Thus, this article studies the research question of how the different stakeholders of an interoperable IoT ecosystem can benefit and create value. Therefore, the goal of this paper is to outline the characteristics of an interoperable IoT ecosystem, identifying the relevant stakeholder roles, and analyzing potential business models. We are conducting this study as part of the BIG IoT project, with several industrial and research partners involved.

The remainder of this paper is structured as follows. Section 2 gives an overview of existing studies and related work in this field of research. Section 3 describes the key characteristics of interoperable IoT ecosystems, its stakeholders, and their relationships. In Section 4, we analyze and discuss potential business models for the identified stakeholders. Finally, Section 5 draws conclusions from our findings and points at future work in this field of research.

2 Background & Related Work

In this section, we provide an overview of research on business models for IoT ecosystems.

[1] http://big-iot.eu

A very comprehensive study on the IoT market as a whole and its development can be found in [3]. Based on a view of nine vertical markets, as similarly seen in [5], a market prognosis is presented. The key findings support our goal of enabling interoperable IoT ecosystems: The authors estimate that the potential economic impact of IoT applications in nine vertical markets may be as high as $11.1 trillion per year in 2025. However, interoperability between IoT systems is critical in order to reach this impact, and the authors expect that 40-60 % of potential value is generated through cross-platform IoT applications. Further, the authors identify most sensor-collected data is currently unused, e.g., an oil rig with 30,000 sensors is examined on which only 1 % of the data is being used. Also in such cases, interoperability and facilitated access to the data will help in the future to improve this ratio of data being used.

In [6], two main classes of business models are distinguished. First, *Digitally Charged Products*, which refer to the new possibilities of the digital transformation for manufacturing industries. Second, the *Sensor as a Service* idea, where sensor data are collected, processed and sold. The second group characterizes also the approach of interoperable IoT ecosystems followed by BIG IoT (see Section 3), where IoT data sources are offered by IoT service providers. The St. Gallen business model navigator [7] analyzes 250 business models applied in the past 25 years and identifies 55 patterns being used as basis for innovation of business models in the IoT. The UNIFY project analyzes in [8] a broad range of business models to provide a basis for the dialogue of the European Platforms Initiative[2] (IoT-EPI). The framework captures the challenges of building IoT ecosystem business models considering the heterogeneity of smart node devices at the edge, network technologies, multiple standardisation initiatives, the immaturity of innovation, and the unstructured ecosystems.

Following the above findings we have to distinguish between business models that (1) target end-users of the IoT and (2) those focusing on business to business revenues. The first case includes, e.g., production companies which are digitally upgrading their businesses from product selling to selling services. The second case includes business models which benefit from ecosystems and require centralized marketplaces for services and/or applications. Further, as the IoT combines the physical with the digital world and fosters cooperation between partners from different domains, a huge number of stakeholders with a wide variety of interests are involved. This makes it difficult to overview the wide variety of business models, which can be complex. So in contrast to the so far usual value chains, the more powerful tool of value networks will be useful to identify more complex relationships of participants of the ecosystem (see Section 3.2).

A conclusion of our related work analysis is that most of the current work is focusing on analyzing business models for device manufacturers. Analyses for IoT ecosystem value propositions are currently missing. At this point, our paper extends the current state of art by identifying the relevant stakeholders and their potential business models within an interoperable IoT ecosystem.

[2] http://iot-epi.eu/

3 Characteristics of an Interoperable IoT Ecosystem

This section describes the need for interoperability in order to ignite IoT ecosystems and presents the BIG IoT approach (Section 3.1). Further, we identify different stakeholders and their relationships within such an ecosystem (Section 3.2), in order to derive relevant business models for those stakeholders in Section 4.

3.1 Realizing an Interoperable IoT Ecosystem – the BIG IoT Approach

The fundament of an IoT ecosystem is the "thing", i.e., physical entity with a virtual counterpart that computes / communicates information and may be controllable autonomously or remotely. These things may be directly connected and accessible through the Internet, e.g., a Rasperry Pi or smart phone, which we call a *device-level platform*. They may also be connected through a gateway, which we call a *fog-level platform*, or there is an aggregating *cloud-level platform*, which is deployed on a server [4]. A few prominent examples of cloud-level platforms are thingworx[3], AWS IoT[4], or Xively[5]. There are more than 360 IoT platforms today and the number is continuing to grow [9]. However, the landscape is complex; each IoT platform defines its own interface, data formats, and semantics. This situation is illustrated in Figure 1, which shows the variety of platform interfaces in form of varying shapes on the interface connector.

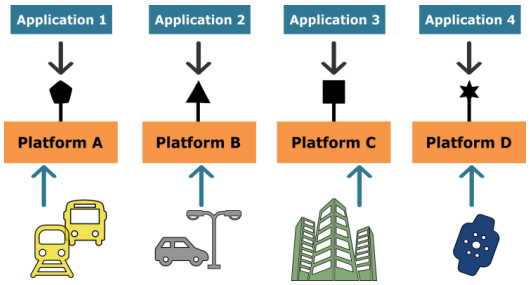

Figure 1: The problem of missing interoperability.

On the one hand, this situation is due to the unavailability of well-adopted standards and shared semantic vocabularies. While work on various IoT standards is in progress (e.g., oneM2M [10] or OMA LWM2M [11]), none of the more high-level standards has reached broad acceptance, yet. On the other hand, the providers of IoT platforms intentionally choose proprietary interfaces. This helps to protect their environment. Once customers have invested in applications using the proprietary interface, the platform has defensible advantages. While this may be an advantage for platform providers once they reach a large customer base, this is a disadvantage for thing providers as well as application developers. The interface heterogeneity makes

[3] https://www.thingworx.com
[4] https://aws.amazon.com/iot
[5] http://www.xively.com

cross-platform applications more difficult to realize since supporting variety of interfaces is costly and increases time to market. Especially, small enterprises cannot afford providing solutions on all different platforms, as they can only provide applications for a small number of platforms, e.g., a traffic information application for one specific city. For thing providers, e.g., the public transport organization of a city, a vendor-lock is disadvantageous as it may develop higher contracting costs in the long-run.

Today, IoT solutions are often in vertical silos with no or little interoperability between them. The BIG IoT project addresses this gap of interoperability between IoT platforms as illustrated in Figure 2. By establishing a common API (visualized as round interface connector), called the *BIG IoT API*, services and applications can easily access different IoT platforms. Thus, in addition to existing proprietary interfaces, platform providers can support the BIG IoT API to take part in the IoT ecosystem. The common place to discover *offerings* of platforms and services is the marketplace. The marketplace offers all stakeholders in the ecosystem the means to trade their offerings. Offerings encompass a set of related information (e.g., low-level sensor data or aggregated information) or functions (e.g., actuation tasks or computational functions). As depicted in Figure 2, we distinguish between services and applications. While the latter only consume offerings, services consume *and* provide offerings.

In this way, platform providers may reach business partners who are otherwise out of reach.

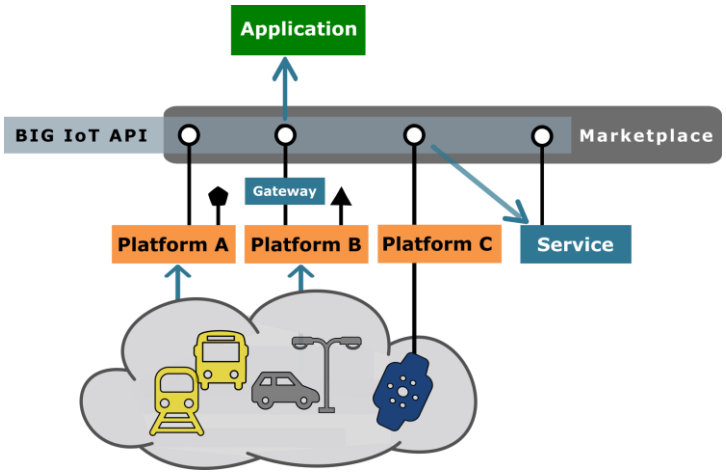

Figure 2: BIG IoT approach towards an interoperable IoT ecosystem.

3.2 The Stakeholders of an Interoperable IoT Ecosystem

In order to better understand the different stakeholders and their motivation in such an IoT ecosystem, as being realized by BIG IoT, we have created a value network model depicted in Figure 3. Value network analysis is a business modeling methodology that visualizes business activities and sets of relationships from a

dynamic whole systems perspective [12]. The nodes in this network represent different stakeholders of the IoT ecosystem. The lines between different nodes are the relationships between the stakeholders. All tangible and intangible value objects that are exchanged between different stakeholders are marked on the corresponding relationships.

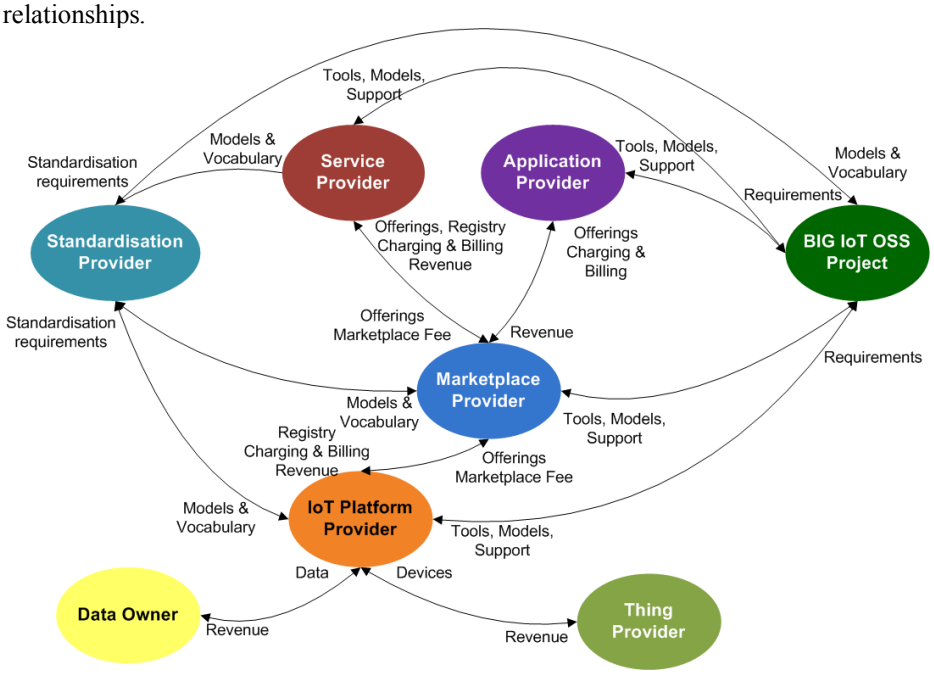

Figure 3: Value Network Model for interoperable IoT Ecosystems.

The *BIG IoT Open Source Software (OSS) project* provides tools, models and support to *Service* and *Application Providers*, *IoT Platform* and *Marketplace Providers* in order to enable them to use the BIG IoT technology to develop their assets. On the other side, these stakeholders provide requirements for further development of the BIG IoT OSS project. The *Thing Provider* operates or sells devices (e.g., sensors or actors) as well as objects equipped with such devices (e.g., traffic lights equipped with radar sensors). He enables the connection of the provided things to an IoT platform. The *IoT Platform Provider* has relations with the *Data Owners* whose data are being collected and provided as offerings on the marketplace. The *Marketplace Provider* on the one side facilitates the trading of offerings by providing means for offering's registration and search, as well as billing and charging for the usage of these offerings in return for the marketplace fee. On the other side, he enables the *Service Provider* to easily discover already registered offerings, build new services and then provide service output as new offerings on the marketplace, in return for the marketplace fee. *Application Providers* use the offerings traded on the marketplace to develop applications for their customers. Last but not least, *Standardization Providers* contribute mainly with models and vocabularies to enable semantic interoperability.

4 Business Model Analyses

As discussed in Section 2, interoperability is needed to exploit the economic impact and all business opportunities emerging from the IoT. In this section, we analyze how the different stakeholders identified in Section 3 can enhance value propositions of their current business models in such interoperable IoT ecosystems. Further, we discuss these business models and identify the importance of a marketplace as a central point of exposition and trading of offerings from heterogeneous IoT platforms and services.

4.1 Business Model Canvases for IoT Ecosystem Stakeholders

For analyzing business models of the different stakeholders of an interoperable IoT ecosystem, we have used the established *business model canvas* methodology with its nine building blocks [13], [7]: Customer Segments (Who), Value Propositions (What), Channels (How), Customer Relationships (How), Revenue Streams (Value), Key Resources (How), Key Activities (How), Key Partnerships (How), Cost Structure (How). In the following, the four business model canvases of the *IoT Platform Provider*, the *Service & Application Provider*, the *Thing Provider*, as well as the *Marketplace Provider* will be described. The inputs for the different building blocks have been assessed according to a survey among the industrial and research partners of the BIG IoT project and also taken from other research and productive ecosystem evaluations and examples.

Business Model Canvas of an IoT Platform Provider

By using the business model canvas (Table 1), we analyze the main opportunities for the IoT platform provider that emerge from the integration with the BIG IoT API and participating in the Marketplace.

An IoT platform value grows if it catches demand both from the side of IoT data providers (e.g., things providers or data owners) and from the side of data users (application/service providers). The main partners of the IoT platform provider are its suppliers (i.e., IT and IoT platform vendors). As the key asset of the IoT platform provider is the content available on the platform, the range of key partners further comprises things providers, marketplace provider, and data owners. In order to take part in the ecosystem, the BIG IoT OSS project as well as standardization bodies are becoming partners to the platform provider, since he can interact with them in order to influence interface definitions.

The core activities of the platform provider are operation on data (their exposure), development of platform services, and sale of those services. To do this, the IoT platform provider exploits storage and computing resources, developing capability, data models, and networking. The key value proposition is strictly linked with exchange and exposure of data, data combination, and operational support. Customer relationships of the IoT platform provider are often strengthened through consultancy and personal assistance devoted to customer segments, such as IoT data users (e.g., service or application providers) and IoT data producers (e.g., public administrations, or utilities). Also, small and medium sized enterprises (SMEs) are often relying as

customers on IoT platform providers, as they do not have the capacity to run their own IoT platform. The main costs are derived from the development, management, and evolution of the IT infrastructure as well as the data maintenance. The IoT platform provider can expect revenue streams from the customers through recurring fees (flat rate model) or through fixed prices based on individual contracts. Also, consulting contracts, e.g., for customizing the platform to specific needs, are possible.

<table>
<tr>
<td rowspan="2">Key Partners

IT Vendors

IoT Platform Vendors

Thing Providers

Data Owners

Standardization Providers
BIG IoT OSS project

Marketplace Provider</td>
<td>Key Activities

Development

Integration

Operation

Sales</td>
<td rowspan="2">Value Proposition

Data provision (domain independent)

Data discovery

Reuse of data and composition

Services for charging and billing

Flexible deployment model

Operational support</td>
<td>Customer Relationship

Consultancy

Self Service

Personalized Support</td>
<td rowspan="2">Customer segments

Public administrations

Public utilities

SMEs

Users of IoT Data</td>
</tr>
<tr>
<td>Key Resources

Developers

Data Centers

Networking</td>
<td>Channels

Web

Sales

References

Conferences</td>
</tr>
<tr>
<td colspan="3">Cost Structure

Development

Integration

Operation

Marketing & Sales

Support</td>
<td colspan="2">Revenue Stream

Flat rate

Fixed price

Consulting contracts</td>
</tr>
</table>

Table 1: Business Model Canvas of an IoT Platform Provider.

By participating in an ecosystem, such as the one realized by BIG IoT, the traditional business model of the IoT platform provider is strengthened, as the IoT platform becomes a product offered through the marketplace connected with the BIG IoT API. Through this registration on the marketplace, the visibility of the platform increases. The key value offered, the access and use of data, is facilitated by relying on a common API. This adds value for the customers and IoT platform users. The above advantages will eventually increase revenue streams.

Business Model Canvas of an IoT Things Provider

"Things" (the real-world objects connected to the IoT) represent the front-end of what the consumer will see, touch and feel when he first interacts with IoT technology. The device's task is to provide functionality and on a second level to interact with other connected objects in order to enhance the capabilities of an

ecosystem and creating more comprehensive scenarios. Things can also generate data, which can be used by other devices or services to better accomplish their tasks. Putting these considerations in the context of BIG IoT, "things" itself can become *first-class citizens* of the larger IoT ecosystem, through equipping them with the commonly defined APIs. By doing so, the business model canvas in Table 2 sketches out the relevant factors of a things provider from a business perspective.

<table>
<tr><td rowspan="2">Key Partners

Module / IC providers

BIG IoT OSS project</td><td>Key Activities

Development

Integration</td><td rowspan="2">Value Proposition

Provisioning of things

Enabling connection of things to platforms

Publishing data through common API</td><td>Customer Relationship

Support in utilization of things</td><td rowspan="2">Customer segments

Public administrations

Public utilities

SMEs

IoT Platform Providers</td></tr>
<tr><td>Key Resources

Developers</td><td>Channels

Sales representatives

Marketing channels</td></tr>
<tr><td colspan="2">Cost Structure

R&D

Development

Operation

Sales & marketing</td><td colspan="3">Revenue Stream

Fixed price per unit (if things are sold)

Operation contracts (if things are operated for third party)

Support / service contracts</td></tr>
</table>

Table 2: Business Model Canvas of an IoT Things Provider.

Apart from providing the things, the value proposition of the thing provider is to facilitate the connection of the things with IoT platforms. This process is supported through common APIs, such as the BIG IoT API. Additionally, the common API can mask hardware complexity and abstract from the challenges of the underlying hardware by exporting a comprehensive and common interface. Among the ecosystem partners of the thing provider are module and integrated circuit (IC) manufacturers, who provide the components on which the design of the product is based, as well as the BIG IoT OSS project, which offers software that can be reused to integrate things. Key resources to be invested are developers that realize the hard- and software. They implement the API as well as device-level applications and ensure that the process of development is smooth. Once a common and open API is chosen, the audience of developers can be extended by externals, which results in overall benefits for the ecosystem. The main cost drivers are R&D, operation, sales and marketing. The revenue stream is either coming from the operator of the things (in case thing provider sells things) or is coming from operation contracts, in case the thing provider is in charge of operating. Additionally, contracts to support the utilization of things may generate revenue. A model that will presumably become more and more important in the future is the generation of revenue through offering things as a service (e.g., railway companies may acquire entire locomotives on service

basis, i.e., they pay the things provider per day of operation). Such service model contracts are further supported through common APIs, as defined by BIG IoT.

Business Model Canvas of a Service / Application Provider

The service and application providers have a crucial role in an IoT ecosystem, as they bring additional value on top of the IoT platforms. Table 3 outlines business model considerations from their perspective.

<table>
<tr>
<td rowspan="2">Key Partners

IoT Platform Providers

Standardization Providers

BIG IoT OSS Project

Marketplace Provider</td>
<td>Key Activities

Development

Operation</td>
<td rowspan="2">Value Proposition

Higher value information

Added-value functionalities

Enrichment through value-chain

Common API facilitates integration</td>
<td>Customer Relationship

Support

Consulting</td>
<td rowspan="2">Customer segments

Application Providers (using a service)

Service Providers (using a service)

Business users (e.g., an organization using an application)</td>
</tr>
<tr>
<td>Key Resources

Developers

Marketing & sales</td>
<td>Channels

Web or direct marketing</td>
</tr>
<tr>
<td colspan="3">Cost Structure

Development

Operation

Marketing & sales</td>
<td colspan="2">Revenue Stream

Pay per use

Pay per install (in case of applications)

Support / service contracts</td>
</tr>
</table>

Table 3: Business Model Canvas of a Service /Application Provider.

The service provider as well as the application provider offer a number of value propositions within an interoperable IoT ecosystem. Based on lower-level input (i.e., an IoT platform or another service), a service or application can offer either higher value information (e.g., weather forecast based on temperature, humidity, and wind measurements) or added-value functionalities (e.g., switching light off in entire building based on single light switches). This enrichment through the chaining of offerings from different parties is valuable for customers. By utilizing the common API or even exposing it (in case of services), the integration with other components of the IoT ecosystem becomes easier. Hence, customers are again other application- or service providers with high-level capabilities, or also business users, e.g., organizations which utilize an application. Relationships to these customers can be maintained through support or even specific consulting. These activities are also a possible revenue stream, apart from the pay per use or a direct payment for the service / application. The key partners of the service and application provider are IoT platform providers, marketplace provider, BIG IoT OSS project, standardization providers as well as developers. The main activities are development, operation and marketing.

Business Model Canvas of a Marketplace Provider

In the previous canvases we presented how the different stakeholders can enrich their value proposition to their customers by participating in an IoT ecosystem, e.g., through the BIG IoT solution. The following business model canvas (Table 4) summarizes the value proposition of the Marketplace to these stakeholders.

<table>
<tr>
<td rowspan="2">Key Partners

IoT Platform Providers

Standardization Providers

BIG IoT OSS Project

Developers

IT vendors</td>
<td>Key Activities

Development

Operation

Product Management</td>
<td rowspan="2">Value Proposition

Discovery of offerings

Advertisement of offerings and broadening of customer outreach

Charging and billing

Management of common vocabulary</td>
<td>Customer Relationship

Support

Consulting</td>
<td rowspan="2">Customer segments

Service Providers

IoT Platform Providers

Application Providers</td>
</tr>
<tr>
<td>Key Resources

Developers

Marketing & sales</td>
<td>Channels

Web and direct marketing

Platform, service, and application vendors</td>
</tr>
<tr>
<td colspan="3">Cost Structure

Development

Operation & infrastructure

Support

Traffic generation and retention</td>
<td colspan="2">Revenue Stream

Advertising fees

Pay per use

Percentage of each payment

Entry fees

Support / consulting contracts</td>
</tr>
</table>

Table 4: Business model canvas of marketplace provider.

The key value proposition of the marketplace is enabling the discovery of offerings from IoT platforms or value adding services. This discovery is provided as searching capabilities on a user interface, as well as through a machine readable API. Applications are specifically not listed in the marketplace of BIG IoT, as there are already many established app stores for this purpose. Nevertheless, also application providers (besides service- and platform providers) are the main customers of the marketplace. All stakeholders profit from the advertisement (or: "marketing") capabilities of the marketplace, which broadens the customer outreach of those offering providers. The discovery and advertisement of offerings is supported through the management of common vocabularies, supported by the marketplace. This is the key to semantic interoperability within an IoT ecosystem. Common terms (e.g., "traffic light" or "temperature"), which are used by multiple participants of the ecosystem, are registered and referenced at the marketplace. Beyond these capabilities for reaching interoperability, the marketplace supports charging and billing. I.e., a service or platform can state how much access to their offerings costs and consumers

of those offerings have to pay. Through these functionalities, the marketplace enables the monetization of IoT offerings.

To operate a marketplace, its provider mainly invests into development and operation, but also product management (i.e., marketing, feedback, promotion, sales) is a key activity for success. Thereby, customer relationships can be initiated through consultancy, customizing assistance, and support. Then, revenue streams will be generated through contractual work for those activities. Apart from those, the marketplace has several interesting possibilities for creating revenue based on different payment models. These range from fees for better advertisement, over a pay per use (e.g., counting API calls), small participations in each payment, up to entry fees for service and platform providers to enlist their offerings.

4.2 Discussion on IoT Ecosystem Business Models

The analyses above show that for each stakeholder, business models can be identified within an interoperable IoT ecosystem. From our perspective, all stakeholders can profit from interoperability and the creation of an IoT ecosystem. Naturally, their effectiveness can only be evaluated in practice. However, the success of an IoT ecosystem will depend (a) on the willingness of IoT platform providers and platform vendors to adopt common APIs into their platforms so that a sufficient offer of data is available and (b) on the number of service and application providers to use these and add value to the data via their offerings. I.e., the lower the initial barriers to enter the ecosystem and a marketplace, the more likely will be the success.

Once a marketplace is established, IoT offerings of platforms and services can be easier found and used to create new, innovative applications. By means of semantic search of offerings, service- and application providers can find resources from different platforms and domains that best fit their needs. Additionally, by using a common API and vocabularies a service provider can more easily provide and trade its offerings. In this way, they can more rapidly deliver services to their existing customers and reach new customers. Furthermore, by using charging and billing of the marketplace they can outsource these activities.

As discussed in Section 3, value chains are evolving towards a value network comprising multiple stakeholders in the ecosystem. When taking the primary functionality of providing a marketplace for the offerings, a general view on the clients of the marketplace only distinguishes between offering providers and offering consumers, as shown in Figure 4.

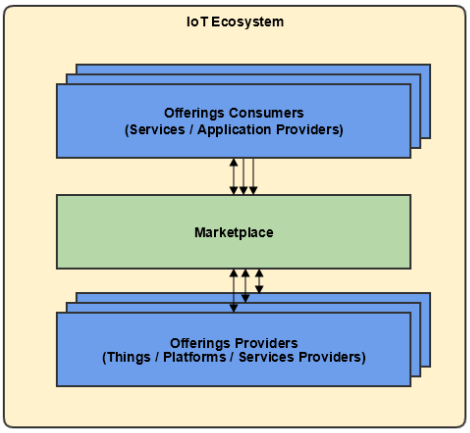

Figure 4: The marketplace as centre piece of an interoperable IoT ecosystem.

By bringing together the offering providers (things / platforms and service providers) and the offering consumers (services and application providers) even for more than one service used in the overall value chain of an application and across all vertical segments, the marketplace utilizes the exploitation across the complete value network of an IoT ecosystem. The marketplace even pushes the utilization for all involved ecosystem stakeholders due to interoperable APIs and the advanced discovery as well as monetization facilities.

To evaluate from an application / industry point of view the value and benefit, we have to investigate in the future through the lens of individual industries or sectors (see [3] and [14]). The existing vertical customer segments of whole industries will be affected by enhancement of IoT capabilities. They will cover more or less all market sectors, but with respect to IoT some will gain more potential than other. In particular, the following vertical markets are important for the IoT [3]: Factories, Cities, Retail environments, Work sites, Vehicles, Agriculture, Outside, Home, Offices. The interoperability and marketplace create value for business users across settings and sectors. As a marketplace can provide presentation and promotion of the offerings relevant across multiple vertical segments as well as semantic search options, the ecosystem is stimulated to push inter-segment and intra-segment value generation as illustrated in Figure 5.

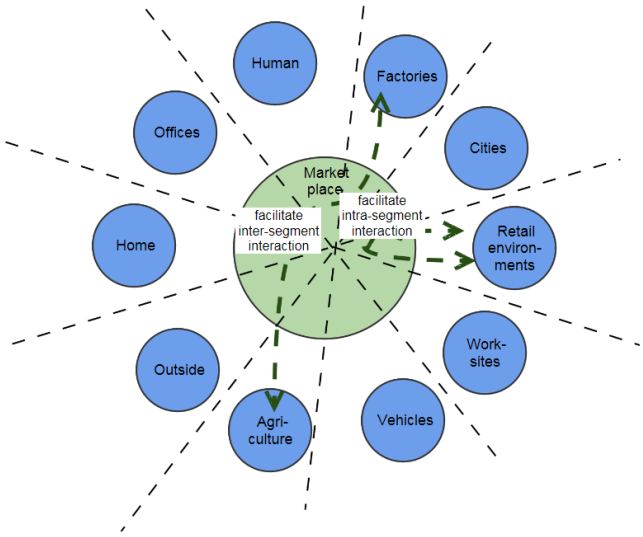

Figure 5: Marketplace facilitates inter-segment and intra-segment interaction.

5 Conclusions & Outlook

In this paper we present an overview of the IoT ecosystem and its stakeholders and the advantages interoperability can bring for them. Starting from a description of the BIG IoT solution, as a realization of an IoT ecosystem, we argue that interoperability brings new business opportunities for all participants in such an ecosystem. By using the value network model analysis we identify the key stakeholders, relationships, as well as tangible and intangible value exchange between different roles. Further, based on the business model canvas method, we analyze existing business models of four key stakeholders and identify how these models are being enhanced through an interoperable IoT ecosystem to provide more value to their customers. In our discussion, we identify the marketplace as the fulcrum of such an ecosystem, and we explain the importance of this role for the inter-segment and intra-segment interaction.

In the future, we will further study the final designs of revenue schemes and which business models are most suitable for the economic success. This work will be done alongside the implementation of three different pilots of the BIG IoT project in Barcelona, Berlin/Wolfsburg, as well as Piedmont. Furthermore, we will investigate how orchestration between all kinds of IoT services and offerings can be supported through the marketplace. Automated orchestration promises to reduce costs through less adaption efforts and empowerment of IoT end-to-end use cases.

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