An Agile Framework for Modeling Smart City Business Ecosystems

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Abstract: Modeling business ecosystems enables ecosystem stakeholders to take better-informed decisions. In this paper we present an agile framework for modeling a smart city business ecosystem. We follow a design science research approach to conceptualize the agile approach to manage ecosystem models and present the architecture of our framework as design artefact. During the design process, we evaluated ecosystem models that need to adapt with the emerging structures of the business ecosystem. The platform aims at a collaborative modeling process, which empowers end-users to manage the business ecosystem models and underlying data. The evaluation of the platform was conducted with industry partners as part of the presented smart city initative, indicating it usefulness when fulfilling modeling related tasks.

1 INTRODUCTION

Digitalization has long reached cities and is changing urban mobility. Digital technologies are progressively integrated to vehicles, traffic systems, and infrastructure. Internet of Things (IoT) devices for instance include sensors that provide information about occupied or available parking slots. The created technological affordances are thereby changing the mobility opportunities and demands of travelers (Mitchell, 2010). The variety of services enabled by digital technologies currently ranges from providing timely information on the traffic situation, to buying tickets for public transportation online, to car or bike sharing services, etc. The services usually comprise consumer-facing mobile applications that rest on digital platforms integrating various underlying services.

This technology-driven opportunity space creates a growing market that challenges established mobility providers such as automotive OEMs, their tier 1 to 3 parts suppliers, but also public transportation providers. One challenge originates from technology startups deploying new IoT technologies such as sensor technology, augmented reality or artificial intelligence to urban mobility. Tech giants such as Google and Apple are also entering the mobility markets globally, by developing self-driving cars and pushing autonomous driving (Etherington and Kolodny, 2016), (Taylor, 2016). As a result, new business ecosystems are currently emerging around mobility markets that are geographically focused on specific metropolitan areas. Besides commercial mobility providers, cities, public institutions and their governments are addressing these challenges as part of their urban development policies concerning smart city concepts. They increasingly become actors within the emerging mobility business ecosystems.

Understanding the evolution process of such mobility ecosystems is instrumental for developing public policies, for taking strategic decisions about business and technology partnerships, or for identifying gaps in the service provision to consumers (Basole et al., 2015a). Hence, the proactive management of the business ecosystem is gaining relevance for firms as well as city authorities (Basole et al., 2015a). Particularly, firms have to adapt their own competencies to their specific (part of the) ecosystem to achieve complementarity (Leonardi, 2011), (Rehm and Goel, 2017).

Our research contributes to this issue by providing a community-based, agile approach to model and visualize smart city mobility business ecosystems. We base our insights on own software engineering design work and a field test of the developed system. The case study is part of a smart city initiative pursued by a European city with a population of more than 2.5m in its urban area and more than 5.5m in its metropolitan region. The mobility ecosystem is anticipated to embrace more than 3.000 firms in the automotive, traffic and logistics sectors residing in the urban area

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and more than 18.000 firms in these sectors in the metropolitan region.

1.1 Problem Statement

Visualizing data is a widely used approach to derive value from data by spotting anomalies and correlations or identifying patterns and trends (Vartak et al., 2017). This holds true for the context of business ecosystems, as visualizations of ecosystems have proven to enable ecosystem stakeholders to take better informed decisions (Basole et al., 2016), (Huhtamaki and Rubens, 2016), (Evans and Basole, 2016). In the context of visual decision support, visual analytic systems (VAS) have been proposed and evaluated to leverage related benefits (Park and Basole, 2016), (Park et al., 2016). These systems allow addressing needs and demands of diverse user groups through different views and types of visualizations (layouts). VAS system architecture comprises elements for interaction of users, for interpreting the visual input, and for generating meaningful reports (Park et al., 2016).

One success factor of visualizing ecosystems is the availability of ecosystem data used for these visualizations (Park et al., 2016). Ecosystem data comprises (a) technology-related data, such as available services, technological standards and platforms, monitoring data sources, (b) business-related data, such as information about service providers, their strategies, partnerships and offered solutions, cooperative initiatives, as well as (c) market-related data, such as regional coverage of services, user types (commuter, tourist etc.), or use patterns of mobile service apps. Ecosystem experts and data scientists together evaluate and interpret the data to create tailored visualizations.

Research addressing ecosystem models and visualizations has used sets of data collected from commercial databases on business and economic data or drawn from social or business media (Basole et al., 2015a), (Basole et al., 2015b). The required variety of data sources effects extensive data collection efforts, also requiring editorial revision of collected data. Data evaluation is therefore often executed only for a specific timeframe, resting on static data sets.

As the structure of the mobility ecosystem in focus is just emerging, the VAS ecosystem model, comprising data model and view model which are used to generate and visualize structures, must be adaptable to address changing data sets. Regarding the data model, e.g., new service providers must be linked to the right types of services or positioned in the market but can also constitute new types of firms or exhibit new types of relationships that subsequently need to be created in the data model. Regarding the view model, in general-purpose VAS, visualization are often not adaptable without high effort. Thus, the view model needs to have the capability to include new structures from the data model.

In addition to these aspects concerning data sources and technical requirements, the data collection and editing process as well as the visualization process face further challenges. For editing data, team-oriented approaches provide a way to cope with the complexity and heterogeneity of data sources and business/technology contexts to cover. As this editing process generates the input to the visualization process, both processes need to be linked within the VAS in order to provide high flexibility for interacting and interpreting with help of the visualization user interface, to define relevant key indicators and to create tailored reports.

1.2 Contribution

Our approach addresses the aforementioned challenges by suggesting an agile approach to collaboratively manage and adapt business ecosystem models and visualizations. We have developed a VAS we refer to as Business Ecosystem Explorer (BEEx), intended as a framework for understanding emerging structures of smart city business ecosystems. This agile framework allows to collaboratively aggregate and map data about the ecosystem, define analytic structures and create multiple types of views, thus providing a customizable instrument for different ecosystem stakeholders as users of the system. Data about the ecosystem allows to visualize the past development of the considered ecosystem and enables stakeholders to analyze present structures, e.g., which company positioned itself as key player within the ecosystem (Basole et al., 2015b).

We provide insights from the prototypical use of the framework developed by us in our case study of a large European smart city initiative. We focus on the iterative and emergent character of the process to collect, edit and visualize data, including the feedback loop stimulating review of gathered data and structures, and re-formatting of visualizations to customize them for different stakeholder needs. This feedback loop is the source of several requirements concerning adaptability and collaborative use of the VAS (Leonardi, 2011), (Majchrzak et al., 2002). In response to that, we conceptualize the ecosystem modeling process by focusing on stakeholder roles as well as visualization and interactivity aspects. After describing our methodological approach, we present related research and basic features of our tools data and visualization models. Then we describe the iterative approach to collaboratively manage and adapt business ecosystem models, highlighting features that allow for an agile data management. We lastly provide considerations on limits and future research with respect to two possible use cases for ecosystem VAS.

2 APPROACH

We have adopted a design science research approach (Hevner et al., 2004), (Hevner and Chatterjee, 2010). This perspective suits our research context of a case study that is part of a European smart city initiative. In the metropolitan region in focus, the structures of the mobility ecosystems are currently emerging as effected by public authorities re-evaluating their policy and regional development activities, and businesses trying to co-shape the evolving mobility ecosystem. Our design artefact is a visual analytic system (VAS), the Business Ecosystem Explorer, which is particularly instrumental to provide tailored visualizations to different stakeholders supporting them in their business- or policy-related tasks and decisions. According to Hevners three cycle view of design science (Hevner et al., 2004), (Hevner, 2007), our research contributes in the following ways to each of the cycles.

Relevance Cycle: The aforementioned challenges linked to smart city and urban mobility provide the boundary conditions to our case study. In the evolving ecosystem, application of the Business Ecosystem Explorer is expected to improve the visibility and understanding of ecosystem structures. We provide data from its prototypical use including expert (user) feedback, in order to assess its utility in practice as well as the viability of our approach.

Design Cycle: We use an established Knowledge Management System application development platform to implement the VAS as design artefact. This platform contains functionality for data management, collaboration, and decision support. The system particularly provides features to address both data and view model adaptation. We draw on recent visualization research to identify and implement five apt visualization types. As in its current stage, the system is able to adapt data and view models to implement further visualizations, we seek evaluation in the relevance cycle by conducting a prototypical field test and including expert feedback which might stimulate further developments.

Rigor Cycle: We have studied and evaluated literature and existing artefacts in the domain of visualizing and particularly, business ecosystem analysis. We draw on the current state of the art in modelling approaches for data visualization and modeling. In addition to the Business Ecosystem Explorer as design artefact, we contribute to the knowledge space by proposing an agile and collaborative process to manage and adapt business ecosystem models.

3 RELATED WORK

3.1 Business Ecosystem Modeling

Since the conceptualization of business ecosystems by James Moore in the mid-1990s, who defined it as a collection of interacting companies (Moore, 1996), the concept has been widely studied (Guittard et al., 2015). Ecosystems are interconnected through a complex, global network of relationships (Basole et al., 2015b). In a business ecosystem, firms take on roles such as suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations (Iansiti and Levien, 2004), all affecting the characteristics and boundaries of the ecosystem. As firms continuously enter and leave the ecosystem (Park and Basole, 2016), they constantly evolve and exhibit a dynamic structure (Peltoniemi and Vuori, 2004). Research on business ecosystems has recently highlighted the role of novel challenges for ecosystem formation, including technology contexts, e.g., the Internet of Things (IoT) (Iyer and Basole, 2016) or policy contexts, e.g., smart city (Visnjic et al., 2016). This has focused researchers attention on ecosystem modeling (Uchihira et al., 2016). Current approaches focus on frameworks to grasp the scope of ecosystem complexity (Iyer and Basole, 2016), (Visnjic et al., 2016), or on visualization to understand emerging structures and patterns (Leonardi, 2011), (Iyer and Basole, 2016).

Ensuing previous research, our business ecosystem model takes into account both the static network of entities (firms, technologies), and the dynamic network characteristics, i.e., the relationships between entities, and activities, all changing over time. Entities comprise small firms, large corporations, universities, research centers, public sector organizations, (...) other parties [and human actors], which influence the system (Peltoniemi and Vuori, 2004). They are linked through a variety of different relationship types. All elements are to be integrated into the visual analytic system (VAS). Which entities and relationship types need to modelled depends on the requirements put forward by the VAS users, i.e., the (business) stakeholders. Their needs and demands that define which (visual) views are relevant, and which

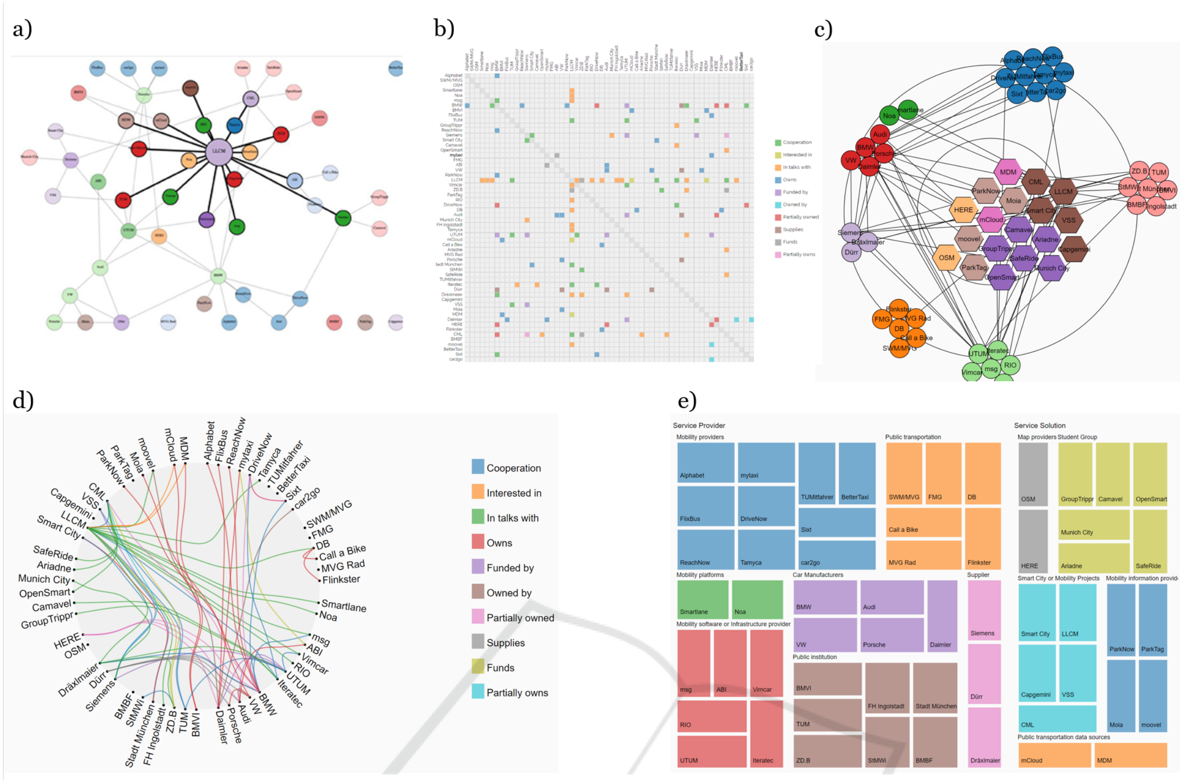

Figure 1: Visualization types of the Business Ecosystem Explorer (BEEx): a) Force-Directed Layout (FDL), b) Matrix Layout (MXL), c) Modified Ego-Network Layout (MEL), d) Radial Network / Chord Diagram (RCD), and e) Tree Map Layout (TML).

insights are vital, are fundamental for generating and adapting the model.

3.2 Business Ecosystem Visualization

To foster understanding of business ecosystems, Park et al. have presented a VAS (Park et al., 2016) that addresses three salient design requirements of the particular problem context of supply chain ecosystems. Their work includes extensive research in the areas of modeling, visualizing and analyzing across different types of business ecosystems (Peltoniemi and Vuori, 2004), (Iyer and Basole, 2016), (Visnjic et al., 2016), (Evans and Basole, 2016), (Park and Basole, 2016), (Basole et al., 2016). The described VAS offers multiple views within an integrated interface, which enable users to interactively explore the supply network. The system additionally provides data-driven analytic capabilities. The authors suggest and test five visualization types (layouts) to visualize the dynamic networked structures of their problem context (Fig. 1).

These layouts comprise Force-directed Layout (FDL), Tree Map Layout (TML), Matrix Layout (MXL), Radial Network/ Chord Diagram (RCD), and Modified Ego-Network Layout (MEL). Each of these layouts provides for interactive features, such as clicking, dragging, hovering, and filtering. We use these layouts suggested by previous research to approach the design of the VAS in our problem context. In addition to these visualization types further ones exist, which focus on particular aspects and perspectives on ecosystems, such as cumulative network visualization (Evans and Basole, 2016), or bi-centric diagrams that visualize the relative positioning of two focal firms (Park and Basole, 2016), (Basole et al., 2016).

Current research on ecosystems at large uses data-driven approaches, i.e., sets of data are collected from commercial databases on business and economic data, or drawn from social or business media (Evans and Basole, 2016), (Park and Basole, 2016). This approach implies that the VAS user, e.g., the strategy team of a company, needs to understand requirements for relevant sources of data that inform the ecosystem model, as well as questions that guide visualizations. Accordingly, both model and visualizations need to be adaptive to host diverse business perspectives and intentions. For the use of the resulting VAS it is thus plausible to assume that business or public authority users might create their own VAS instance that focu-

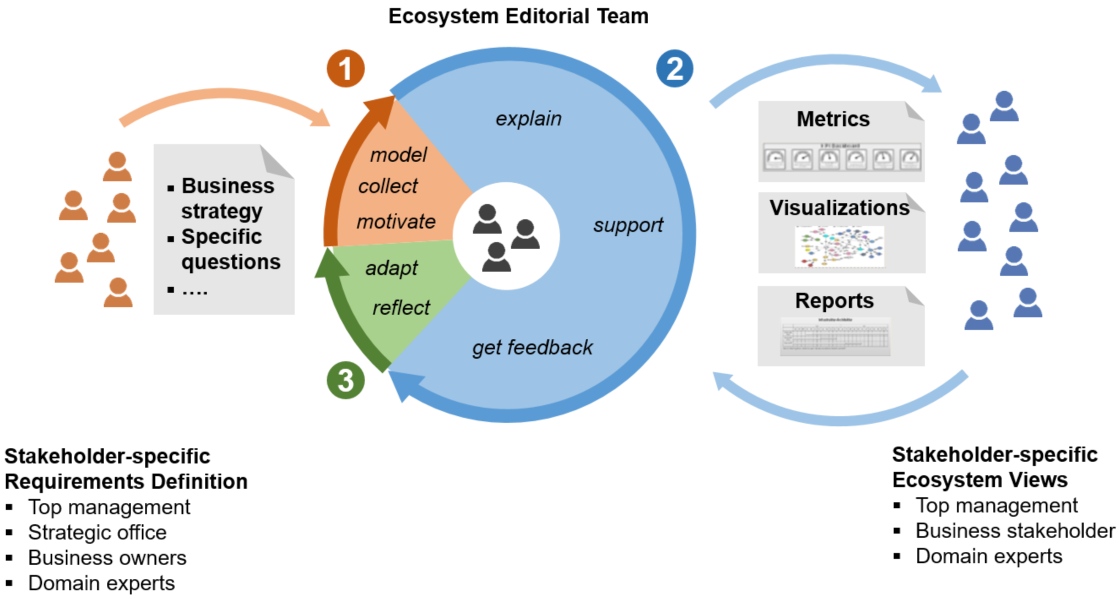

Figure 2: Agile process to collaboratively manage and adapt the business ecosystem model.

ses on distinct data sources and structures. In the following, we therefore highlight the process of ecosystem modelling.

4 AGILE APPROACH TO ECOSYSTEM MODELING

This section describes the process and roles necessary to collaboratively manage and adapt business ecosystem models, and to visualize the models. We envision a process that is adaptable to different types of teams, or communities. On the one hand, enterprise internal working groups can constitute the stakeholders of an ecosystem modelling initiative. On the other hand, a public ecosystem model and VAS can be conceived that serves both the public and policy makers. Independent of these use scenarios, several roles need to be represented that we present in the following.

4.1 Agile Modeling Process and Roles

Our approach comprises three phases that constitute an iterative procedure to initially build, use, and revise an ecosystem model (Fig. 2) (Roth et al., 2014).

First, the build phase comprises activities to motivate creation and use of the VAS, collection of data about/from the ecosystem, and carry out the modelling. Basic requirements for engaging into an ecosystem modelling initiative stem from the core stakeholders such as an enterprises top management or strategy team. Together with domain experts, e.g., business case owners, specific questions about the ecosystem, its development or structures are formulated. These mirror the business strategy that underlies the initiative at large. (For reasons of simplicity, we apply the use scenario of an enterprise, but roles will correspond to use in a public policy maker scenario, too). These requirements are taken up by a team (role) we named Ecosystem Editorial Team. This group is responsible for collecting data and modelling. (It is conceivable that for public use, a separate, public or third party funded editorial office is created that overlooks and eventually investigates on, ecosystem data sources).

For the initial instantiation, company internal information systems are used as data sources, providing already collected information about competitors, business partners, etc. Additionally, each stakeholder group is motivated to implement their specific knowledge documented locally and to communicate the sources used to gather information. Within the iterations of the build phase, these sources are used to collect continuous information, both manually but also automatically from news feeds, blocks, etc., both orchestrated by the Ecosystem Editorial Team. Finally, the stakeholder groups should be kept motivated to contribute with information whenever possible. (For public use, available data sources, both international, such as Crunchbase[1] or Anglelist[2], and nati-

[1] https://www.crunchbase.com
[2] https://angel.co/

onal, for Germany e.g. Grunderszene[3] or Bayern-International[4], are used for the initial build phase. In the next iterations, the data gathering extends to crowdsourced data provided by the stakeholder also using the provided metrics, visualizations, and reports. Also, automatic news feeds evaluation are included to enrich the data base. It is within the responsibility of the mentioned editorial office to supervise this process.)

In this phase, each stakeholder group owns specific requirements towards both, understanding the ecosystem as well as the functioning and use of the VAS. In our case study, for the Business Ecosystem Explorer prototype, requirements from several stakeholders groups were collected; each group provided particular demands with regard to relevant entities, and creation of views. For instance, legal department representatives were rather interested in legal forms and business relationships of business partners, while a strategy team focused on platforms and technologies related to ecosystem members and cooperative initiatives, to inform the search for potential future business partners. The requirements are inititally collected in workshops lead by the Ecosystem Editorial Team with each stakeholder group. In a later phase of the VAS, the requirements are gathered within the VAS.

Second, the use phase covers presentation (execution) of the created model within different layouts, interactions between users and the layouts to analyze the ecosystem, and feedback to the Editorial Team in order to fine tune or revise the model. In our case study, the business ecosystem model is presented through stakeholder-specific ecosystem views that include metrics, e.g., key values about centrality or connectedness of an entity, different visualizations, and reports. Reports play an important role in the communication process (Roth et al., 2014) and for explanation, as they contain the interpretation of data and visuals by the domain experts, top management or business stakeholders as users. This interpretation at a specific point of time serves as input to further analysis and revision, and helps to follow the emergence of structures or patterns at a later stage.

Third, the revision phase comprises the reflection on achieved results and validity of the model/provided visuals as well as the adaptation of model and requirements. In this phase, additional input from external domain experts can be sought depending on upcoming tasks (Basole et al., 2016). A key role in this process is assumed by the Ecosystem Editorial Team, whose modelling expert members particularly require some domain knowledge about modelling. The team should be capable of managing the various stakeholder groups, deliver stakeholder-specific visualizations and safeguard the process cycle. The task of ecosystem experts holding domain knowledge about business or regional factors etc. is to collect information from the ecosystem and prepare it in the right format as content of the ecosystem model.

In our case study, as for the requirements put forward by the modelling process, we have implemented the ecosystem model and the VAS into an integrated, adaptive collaborative work system. This systems ecosystem model is capable of integrating all stakeholders requirements and visualizations, and thus grows with increasing demands and solutions, e.g., visuals that comprise selected entities and relationships to answer specific questions about the ecosystem. This integrative aspect is particularly relevant, if one unique system is to be developed for use by a larger ecosystem initiative, as is the case in our case study context of a smart city initiative. Multiple stakeholders including public and private organizations might then become users of the ecosystem model.

4.2 Adoption and Agility Aspects

From our field test, we have seen that it is vital to ensure involvement of different stakeholder groups, and to keep them motivated to discuss and explore the model across process cycles. In this respect we have experienced that it is helpful to present an early version of the business ecosystem model and visualizations to address specific demands (Roth et al., 2013). Further, we have noticed that the availability of varied visualizations can stimulate cross-contextual thinking, which might lead to formulation of new key values in interpreting the ecosystem, e.g. transitive relationships that express the indirect closeness between entities.

As a result, each of the phases should be implemented as interactive and collaborative processes to enable early adaptation and validation of formulated requirements (Roth et al., 2013). Additionally, different stakeholders should be able to adapt and evolve the business ecosystem model and visualizations without having software development skills. Thereby, the collaborative process must be supported continuously by an information systems, which allows the end-users (i.e., users without software development skills) to modify the business ecosystem model and visualizations at run-time (i.e., without the need to stop and recompile the system to integrate new functionalities). In this sense, we use the term agile to characterize the way in which the process from require-

[3] http://www.gruenderszene.de/

[4] http://www.bayern-international.de/en/

ments definition to visualization and feedback should be managed.

5 DESIGN ARTEFACT: AN AGILE FRAMEWORK FOR MODELING ECOSYSTEMS

5.1 The Hybrid Wiki Approach to Collaborative Work, and Architecture

The previously described requirements to the ecosystem modelling process caused us to design an agile framework for modeling ecosystems as integrated, adaptive collaborative work system supporting the evolution of both the model and its instances at runtime by stakeholders and ecosystem experts (i.e., users without programming knowledge or skills). Developing and maintaining such collaborative environments can be considered a difficult task. Recent research has suggested the Hybrid Wiki approach to address this challenge (Matthes et al., 2011). The Hybrid Wiki approach has been used in different use cases and domains such as Enterprise Architecture Management (Matthes and Neubert, 2011), (Buckl et al., 2009) and Collaborative Product Development (Shumaiev et al., 2014), (Hauder et al., 2013).

This framework rests on the Hybrid Wiki approach as presented in (Reschenhofer et al., 2016) that serves as Knowledge Management System application development platform and contains features for data management as well as collaboration and decision support. To create the business ecosystem model we use the Hybrid Wiki metamodel.

The Hybrid Wiki metamodel contains the following model building blocks: Workspace, Entity, EntityType, Attribute, and AttributeDefinition. These concepts structure the model inside a Workspace and capture its current snapshot in a data-driven process (i.e., bottom-up process). An Entity contains a collection of Attributes, and the Attributes are stored as a key-value pair. The attributes have a name and can store multiple values of different types, for example, strings or references to other Entities. The user can create an attribute at run-time to capture structured information about an Entity. An EntityType allows users to refer to a collection of similar Entities, e.g., organizations, persons, amongst others. The EntityType consists of multiple AttributeDefinitions, which in turn contain multiple validators such as multiplicity validator, string value validator, and link value validator. Additionally, an Attribute and its values can be associated with validators for maintaining integrity constraints.

The EntityType and AttributeDefinition are loosely coupled with Entity and Attribute respectively through their name. These elements specify soft-constraints on the Entities and Attributes. The use of soft-constraints implies that the users are not restrained by strict integrity constraints while capturing information in Entities and their Attributes. Therefore, the system can store a value violating integrity constraints as defined in the current model.

5.2 Business Ecosystem Explorer Views

The agile framework currently consists of five views; a landing page, detail view with company information, a relation view, a visualization overview, and several visualizations (Fig. 3). For all views, a menu bar at the top of the page provides links to the other views available.

The landing page displays a list of top-level entities as defined in the ecosystem model. For our case study, we have for instance used organizations that are part of the smart city ecosystem. The detail view lists a short text for entity description, attributes such as location, key personnel, legal form, etc., and relations of the entity such as group affiliation, financial or contractual dependencies, etc. The relation view is an implementation of the Radial Network/Chord Diagram (RCD). For a selected range of entities, it highlights different types of relationships. When hovering over an entity on the arc of the circle this entity and all associated relations and entities are emphasized by a bold type, whereas the remaining relations and entities are grayed out. The visualization overview presents various options to select other specific visualization types as separate, more detailed visualization views (Fig. 3).

5.3 Business Ecosystem Model

The agile framework relies on (a) ecosystem data model, and (b) ecosystem view model, each with respective features for creation and adaption. Both models are encoded using the Hybrid Wiki metamodel. The ecosystem data model contains two EntityTypes within the Hybrid Wiki metamodel: organizations and relations. Thereby, organizations are automotive OEMs, their suppliers, public institutions, mobility related projects, etc. The AttributeTypes in the organization are company name, abbreviation, logo, URL, short description, headquarter, CEO, category, and legal form. Additionally, the relations describe different

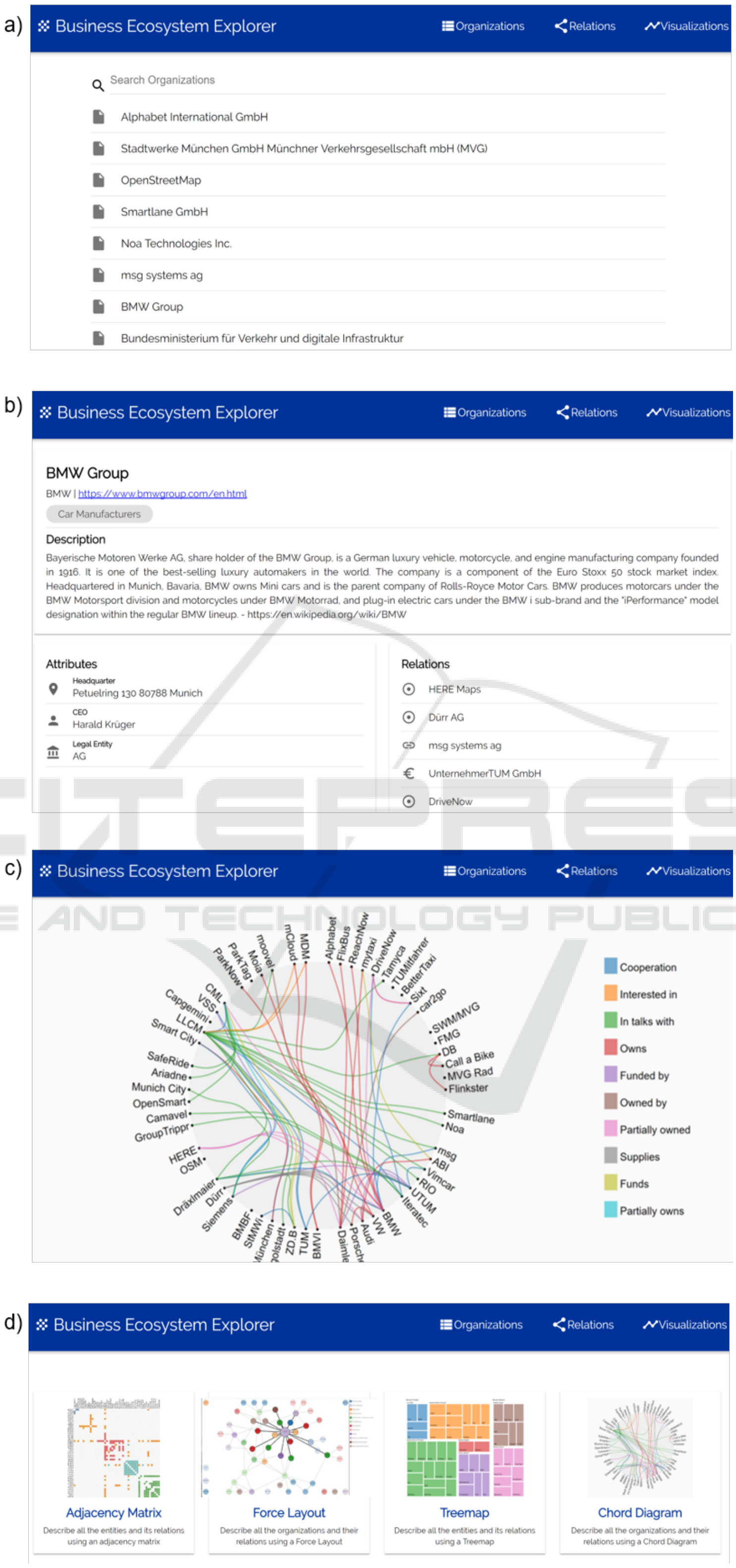

Figure 3: Architecture of the Business Ecosystem Explorer (BEEx): a) A list of all companies, b) Detailed information of the ecosystem entities, c) One view focusing on different types of relations between ecosystem entities, and d) Overview of available visualizations (see also Fig. 1).

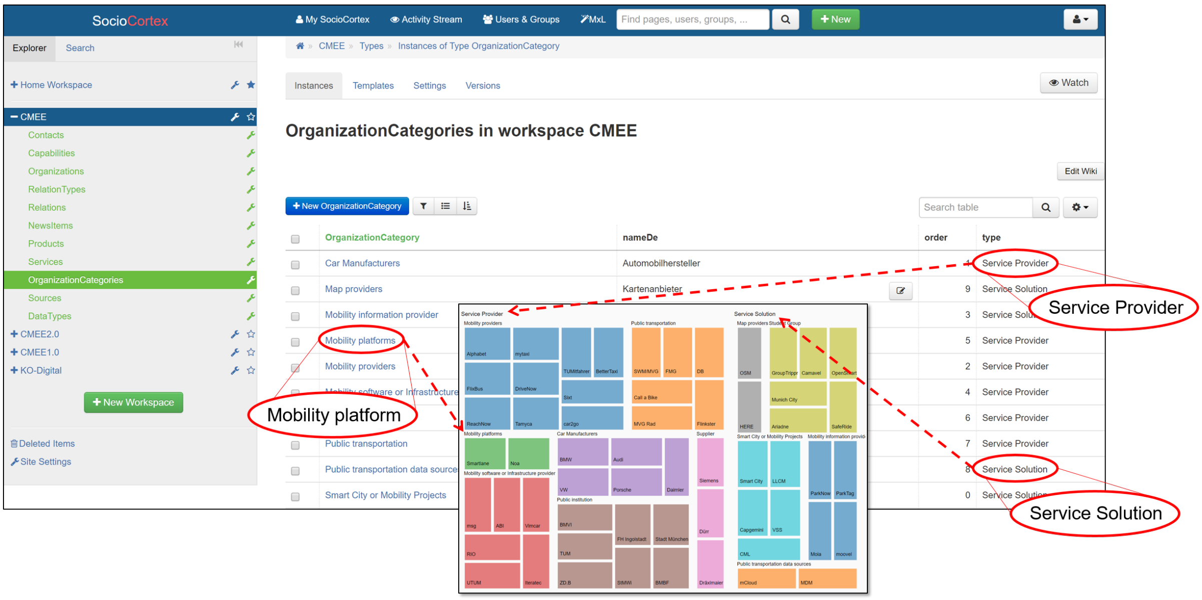

Figure 4: List of Categories and Types in BEEx and conversion to Tree Map Layout (TML).

types of interaction between organizations, as information coming from companies webpages, newsfeed, social media, etc. Therefore, the attributes of the relation are the type of relation, e.g., cooperation, (partially) ownership, funding, etc., involved companies, the date, and the source.

The ecosystem view model is encoded as one EntityType called visualizations. Each visualization has two elements: the first element is the link between the data model and the visualizations. The second element is the specification of the visualizations, which are described using the visual encodings of the visual grammar Vega[5], as presented and described in (Heer and Bostock, 2010) and (Satyanarayan et al., 2016). The Vega visualization grammar introduces a declarative language to describe visualizations in a JSON format. The main building blocks, which enable static and dynamic visualization features, are a) data, including data but also all data transformations; b) marks, covering the basic description of the visualized symbols, e.g., shape and size of a node; c) scales, containing visual variables, such as the color coding; d) signals, including the different interaction options, e.g., dragging and dropping of entities; and in some instances e) legends.

The proposed approach provides the feature of adapting the models at runtime. An example within the business ecosystem scenario is the categorization of organizations. The initial grouping into Car Manufacturers, Map Provider, Mobility Platforms, etc. is pictured in Fig. 4 in the background screenshot.

[5]https://vega.github.io/vega/

This list shows the representation within the collaborative work system. The system provides the feature to adapt the categories at runtime: adding a new category, changing or deleting existing categories. All visualizations using the groups of companies, such as the tree map layout (as pictured in Fig. 4), the chord diagram layout or the modified ego-network layout, are adapted at runtime as well.

5.4 First Evaluation of the Agile Framework

For the evaluation process, the agile framework is hosted on a University server accessible on two Internet sites.

Initially, we conducted nine interviews in semi-structured form with nine different companies within two months, following (Weiss, 1995). We aimed at a balance between receiving a quantifiable evaluation but also enabling interviewees to vary the depth of answer depending on own capabilities and willingness (Gläser and Laudel, 2010). The focus of these interviews was to receive feedback regarding the existing business ecosystem model. Therefore, a sample of attributes was presented, as well as some types of relations and a visualization of the combination of entities through relations in the form of a force-directed layout. All interviewees stated that the business ecosystem model supported them in understanding the relations within the presented business ecosystem and that their knowledge of this ecosystem was increased. Some suggested immediately additional scenarios, for example, the patent management in the pharmaceutical industry.

We used the interviews' results to update the existing prototype. As a next step, we conducted three in-depth interviews with additional three companies. To obtain a wider range of opinions, we selected three companies of different fields of activity. Namely, an automotive OEM, a publicly funded non-research institution and a software company with main business area addresses the connected mobility ecosystem. All interview partners were actively modeling their business ecosystem and all stated their perceived limitations with the current in use tools (mainly Microsoft products in connection with CRM tools in use). Additionally, two companies confirmed that different stakeholders within in the enterprise have different viewpoints towards the enterprise's business ecosystem. All companies agreed that the prototype fosters the understanding of the presented ecosystem and two continued that it would be interesting to use such a tool within in their enterprise to collaboratively manage the business ecosystem evolution.

6 CRITICAL REFLEXION

As visualizations help stakeholders to better understand data, the here presented visual analytic system links the data model and the view model. This enables a dynamic mapping of the view model and the ever changing data model without high developing efforts.

Nevertheless, within the VAS different stakeholders performing various roles are neccessary. This means, on the one hand, the business owner and domain experts have to provide their expert knowledge by providing their data sources and their requirements, but also technological experts within the Ecosystem Editiorial Team providing visualisations, reports and metrics. The quality of the VAS depends highly on the inclusing of these different stakeholders.

Additionally, as visualizations are data-driven, the business ecosystem visualizations rely heavily on the availability and quality of data. The data collection must therefore fulfill quality requirements, which need to be more clearly defined in future research to assure data reliability and validity. To address this demand for structured data collection processes, approaches to data governance are needed. In case of firm-internal usage, this is accomplished by the Ecosystem Editorial Team. In public usage, the data governance role could be assumed by an Urban Data Governance Board.

An extension to the visualization of ecosystems is inclusion of data about the actual use of services from mobile devices and digital platforms, and sensor data from the mobility infrastructure. This might open up new options for identifying missing consumer-facing services as for instance specific mobility services that are not available in a particular region and identification of mobility providers and solutions that can close this gap.

As a final limiting factor, it should be noticed that the presented agile framework prototype is not in its final version as it iteratively evolves.

7 CONCLUSION

In this paper, we report from the field test of a prototypical visual analytic system (VAS) in context of a smart city mobility business ecosystem. We propose an agile approach to collaboratively manage and adapt business ecosystem models and their visualizations. We provide insights from the use of our VAS design artefact, an agile framwork for modeling ecosystems, developed by us as part of a case study of a large European smart city initiative. The agile framwork is based on an application development platform, which provides the feature of adapting the underlying data and view models at runtime. Thereby, we address the need to change the data and the view model according to the emerging structures of the ecosystem.

The results of our field test indicate that additional iterations of the design cycle are required to extend the functionality of the developed VAS tool. Therefore, we envision evaluating the proposed approach within further business ecosystem scenarios, such as the medical and pharmaceutical ecosystem or the legal informatics ecosystem. As a tool improvement step, we envision to adapt existing visualization and add new ones based on feedback from industry partners. In addition, acceptance criteria for ecosystem VAS need to be defined, having in mind the two major use cases mentioned. Measuring the success of ecosystem visualizations in general is a further challenge that will require a broader study of VAS adoption throughout various ecosystems.

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