Collaborative Modelling and Visualization of Business Ecosystems: Insights from two Action Design Research Case Studies

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Abstract

Business ecosystems are increasingly gaining relevance in research and practice. Because ecosystems progressively change, enterprises are required to analyse their ecosystem, in order to identify and respond to such changes. For gaining a comprehensive picture of the ecosystem, various enterprise stakeholders need to be involved in the analysis process. We use an Action Design Research approach to implement a collaborative process for modelling and visualizing business ecosystems in two case studies. We look at the challenges of the collaborative process and study how a model-driven approach addresses these challenges. We validate and discuss the modelling process along six steps; definition of the business ecosystem focus, model instantiation, data collection, provision of tailored visualizations, model adaption, and using visualizations 'to tell a story'. In a cross-case analysis, we draw conclusions with respect to process implementation and the role of visualizations.

Keywords: Business Ecosystem, Collaborative Modelling, Ecosystem Visualization, Case Study, Action Design Research

1 Introduction[1]

Undoubtedly, firms increasingly recognize the relevance of their complex business environment in which they develop, produce and distribute their services and products; this environment is often referred to as *business ecosystem* (Kapoor & Argarwal, 2017; Parker, van Alstyne, & Jiang, 2017; Sako, 2018). The growing relevance of business ecosystems

[1] This paper is an extension of the conference paper entitled "Visualizing Business Ecosystems: Applying a Collaborative Modelling Process in Two Case Studies" by the same authors, published in the conference proceedings of the 29th Australasian Conference on Information Systems, Track: Digital Business Innovation, Sydney, Australia, 3-5 December 2018, where it has been granted the ACS Best Paper prize third place.

substantiates through the perceived shift of the competitive environment from single companies and their supply chains towards ecosystems competing against each other (Bosch, 2016; Parker, van Alstyne, & Jiang, 2017). Addressing the associated challenges and opportunities has thus become a reality for most companies (Peltoniemi & Vuori, 2004). Research on business ecosystems has looked at their networked structure and strategic relevance (Moore, 1993; 1996; Adner, 2016), emphasized their dynamics and evolution (Adner & Kapoor, 2016; Peltoniemi & Vuori, 2004), and discussed aspects such as 'healthiness' or the role of information technologies (Kim, Lee, & Han, 2010; Sako, 2018). Extant research has emphasized that as of today, the economic success of an enterprise significantly depends on its capability to manage and evolve in relation to its business ecosystem (Parker, van Alstyne, & Jiang, 2017; Huber, Kude, & Dibbern, 2017). In this regard, the role of an enterprise within its ecosystem can range from a keystone to a niche player (Iansiti & Levien, 2004).

Despite acknowledging the overall significance of business ecosystems for a single firm, research has remained comparably silent about what exactly a firm can do to analyse their business ecosystem in order to identify and respond to changes within their ecosystem (Basole, Huhtamäki, Still, & Russell, 2016), adapt own business activities accordingly and to "learn what makes the environment tick" (Porter, 1979). One way to support decision makers in their ecosystem-related tasks are *visualizations of business ecosystems* (Basole, Huhtamäki, Still, & Russell, 2016; Huhtamaki & Rubens, 2016; Evans & Basole, 2016). Visualizing information about the firm environment and relationships can help to spot anomalies, identify keystone and niche players, or recognize change patterns and trends prevalent in the ecosystem (Vartak, Huang, Siddiqui, Madden, & Parameswaran, 2017).

However, deriving value from information about ecosystems has proven challenging due to several factors including the nature, availability and volume of required data, as well as data collection and analysis processes (Basole, Russell, Huhtamäki, Rubens, Still, & Park, 2015; Iyer & Basole, 2016; Rehm, Faber, & Goel, 2017). *Ecosystem data* is large and heterogeneous, ranging from technology-related data about applied standards and platforms to use, to market information and legal regulations (Basole, Russell, Huhtamäki, Rubens, Still, & Park, 2015; Faber, Rehm, Hernandez-Mendez, & Matthes, 2018a). When focusing on business aspects of a firm's business ecosystem, information about business partners, competitors, interesting start-ups and their strategies, partnerships and offered solutions, and cooperative initiatives become relevant and need to be integrated into a coherent *business ecosystem model* (Faber, Hernandez-Mendez, Rehm, & Matthes, 2018a). Relevant data can originate from various sources, such as existing databases, newspaper articles or blogs addressing recent developments within the ecosystem, but also company and institutional web presences and publications. Hence, the issues associated to data collection—particularly when taking into account the evolutionary nature of business ecosystems—are not yet resolved (Iyer & Basole, 2016; Hao, Zhu, & Zhong, 2015). This state of play poses particular challenges for generating and analysing visualizations for business development (Rehm, Faber, & Goel, 2017). In addition, from a use perspective, various stakeholders need to be included in the process of ecosystem visualization and analysis who represent the interests of a firm's strategy, business units or functions, and who bring in diverse expertise and perspectives (Rehm, Faber, & Goel, 2017).

We are building on previous research in the domain of *collaborative modelling* that provides an approach for integrating stakeholder groups, including them into cooperative, shared model

creation and evaluation (Dollmann, Houy, Fettke, & Loos, 2011). We aim at providing a *collaborative approach to model and visualize business ecosystems* from a company-internal perspective. Particularly, we address the following research question:

> *What are the challenges of collaborative approaches for modelling and visualizing business ecosystems, and how does a model-driven approach address these challenges?*

Our contributions involve the description of

(1) a process to initiate the modelling of business ecosystems,

(2) important roles during the modelling process, and

(3) lessons learned from two action design research case studies we conducted with two companies of different business ecosystems.

In section 2 we introduce related work regarding the business ecosystem concept, visualization and collaborative modelling of business ecosystems. In section 3, we describe the research method; section 4 outlines the case studies. In section 5 we discuss our case study insights and summarize lessons learned. Finally, in section 6, we provide a short conclusion.

2 Related Work

2.1 The Concept of Business Ecosystem

The term business ecosystem was coined by James F. Moore in the mid-1990s, in analogy to the metaphor of a biological ecosystem (Moore, 1993). Since its introduction that defined it as a collection of interacting companies (Moore, 1993), the concept has been widely studied and used in management science (Guittard, Schenk, & Burger-Helmchen, 2015). The initial definition was enriched by including various roles of firms as "suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations" (Iansiti & Levien, 2004). Thus, the concept of business ecosystem extends the idea of the classic supply chain, consisting of suppliers and customers, by including further entities of a firm's business environment. We define business ecosystems holistically, as the environment of an enterprise including current and potential future business partners and relationships, involving entities such as customers, suppliers, competitors, regulatory institutions, and innovative start-ups. Ecosystems usually exhibit high dynamics as continuously firms enter and leave the ecosystem (see Peltoniemi & Vuori, 2004 for a comprehensive discussion). Therefore, business ecosystems constantly evolve, exhibiting a dynamic structure (Peltoniemi & Vuori, 2004), with not only enterprises but also human actors entering and leaving the ecosystem, which "are interconnected through a complex, global network of relationships" (Basole, Russell, Huhtamäki, Rubens, Still, & Park, 2015), and which all potentially affect business success and failure of other firms active within the ecosystem. The role of a single enterprise within its ecosystem can range from a keystone to a niche player, with varying level of influence on the overall health of the ecosystem (Iansiti & Levien, 2004).

The business ecosystem concept is distinct from extant concepts such as clusters or networks as it focuses on "value-creating activity (…) rather than an industrial sector" (Sako, 2018). In this respect, sustainability, self-governance and evolution have been defined as three meta-characteristics of business ecosystems (Sako, 2018). Current research considers frameworks to grasp the scope of ecosystem complexity (Iyer & Basole, 2016), visualizations to understand emerging structures and patterns (Iyer & Basole, 2016), or policy contexts such as smart city

(Visnjic, Neely, Cennamo, & Visnjic, 2016; Rehm, Faber, & Goel, 2017). In addition, various types of ecosystems have drawn researchers' attention as for instance, the Internet of Things (IoT) business ecosystems, addressing business ecosystem design methods (Uchihira, Ishimatsu, & Inoue, 2016).

2.2 Business Ecosystem Visualization

Visualizations of business ecosystems enable ecosystem stakeholders to take better-informed decisions (Basole, Huhtamäki, Still, & Russell, 2016; Huhtamaki & Rubens, 2016; Evans & Basole, 2016). Research addressing ecosystem visualizations has used data sets collected from commercial databases on business and economic data or from social or business media (Basole, Russell, Huhtamäki, Rubens, Still, & Park, 2015).

Similar to the framework we used in our studies, Park, Bellamy, & Basole (2016) present a visual analytic system for analysis of a supply chain management ecosystem. The authors identify three salient design requirements:

(1) to support multiple views in an integrated interface,

(2) to enable interactive investigation of supply networks, and

(3) to provide data-driven analytic capabilities.

In their scenario, system users are enabled to interactively explore the ecosystem model using multiple views, all integrated in one user interface. In addition, data-driven analytics are provided. The system introduces five network layouts, which are force-directed, circular or chord diagram, tree map, matrix, and substrate-based layout. Thereby, all visualizations provide interactive features, such as clicking, dragging, hovering, and filtering. These authors' further work comprehensively adds to research in the area of modelling, visualizing and analysing business ecosystems (Basole, Russell, Huhtamäki, Rubens, Still, & Park, 2015; Park, Bellamy, & Basole, 2016; Park & Basole, 2016; Basole, 2009a; Basole, 2009b).

2.3 Collaborative Modelling of Business Ecosystems

Collaborative modelling originated in the 1970s and has since increasingly gained relevance, mirroring the increased need for collaboration amongst experts (Renger, Kolfschoten, & De Vreede, 2008). Collaborative modelling has been applied to various research fields, such as business process modelling (Dollmann, Houy, Fettke, & Loos, 2011), enterprise architecture modelling (Roth, Hauder, & Matthes, 2013), or group decision support system modelling (Liu & Zhang, 2010).

Various *roles* have been identified as being essential for collaborative modelling, whereby these roles can be allocated to different persons—or several roles can be assigned to the same person (Richardson & Andersen, 1995; Renger, Kolfschoten, & De Vreede, 2008). Generic roles comprise:

(a) *facilitator*, monitoring the group process and stimulating the model building effort;

(b) *modeller*, focusing on the model outcome;

(c) *process coach*, observing the process and the dynamics of the participants;

(d) *recorder*, documenting the modelling process; and

(e) *gatekeeper*, responsible for the process and major decision maker (Richardson & Andersen, 1995).

However, extant literature does not suggest *collaborative processes* that specifically address business ecosystem modelling and the instantiation of such models.

3 Method

3.1 Action Design Research Approach

Our research intends to provide insights into *challenges of collaborative approaches for modelling and visualizing business ecosystems, and into how model-driven approaches address these challenges*. As we have the aim to inform both research and practice we position our work as action design research (ADR) (Avison, Lau, Myers, & Nielsen, 1999; Baskerville & Myers, 2004; Hevner, March, Park, & Ram, 2004; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). Due to the lack of existing research—or reports from practice—about such collaborative approaches, and in order to comprehensively understand related issues and challenges, we focus our work on *instantiating* such a process (Sherer, 2014). We do this on basis of a collaborative work information system, which we refer to as *Business Ecosystem Explorer (BEEx).* ADR allows generating prescriptive design knowledge while implementing and evaluating design artefacts in distinct organizational settings (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). In our study, the collaborative modelling and visualization processes represent a methodical design artefact, while the employed collaborative work system's visualization capabilities—which have been adapted during our research—represent a technological design artefact.

Our report focuses in particular on aspects of developing, testing and re-configuring the collaborative work system's visualization capabilities as well as the modelling method in direct interaction with the end-users in two case studies. Hence, regarding the ADR research cycle, our case studies can be positioned in a 'beta' cycle of the 'building, intervention and evaluation' stage of ADR in its organization-dominant form that includes operational system use (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011).

3.2 Case Study Design

We have carried out two ADR case studies with two different organizations (Hevner, March, Park, & Ram, 2004; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011; Yin, 2014). In preparing our research, we identified two companies that had not previously engaged with business ecosystem modelling but that demonstrated interest in a project to analyse their ecosystem.

One organization is an automotive company, headquartered in Europe with approximately 120,000 employees. The other is a publishing company, headquartered in Europe with approximately 16,000 employees. Both organizations had a high interest in modelling and visualizing business ecosystems of their specific focus, one related to smart cities and the other to the service and person landscape within their business area. For both, the ecosystem of focus was not yet modelled or visualized.

We conducted several workshops with both organizations between December 2017 and August 2018. In advance, we discussed the study schedule and discussed our earlier work. During the project, we scheduled workshops and meetings on an ad-hoc basis.

3.3 Data Collection and Analysis

We collected data with help of documentation, by examining archival records, and through direct observation (Benbasat, Goldstein, & Mead, 1987). All involved stakeholders had access to the provided collaborative work system *BEEx*, which they used to model their business

ecosystem of focus after an introduction in a primarily self-directed manner. We had access to all aspects of the modelling process and related documentation during the entire study period, which contributed to a shared understanding of the addressed business ecosystems.

As part of both case studies, we conducted several workshops with a high degree of interaction, which provided us with a fertile ground for direct observations. The workshops focused particularly on executing the collaborative modelling procedure to create ecosystem data and view models (see section 4), which represent the distinct outcomes of the process. After each workshop session, we documented our direct observations and eventually adjusted the models in the collaborative work system. In addition, each workshop was documented in form of a report that was validated by company representatives.

In both case studies, final workshops with a larger group of stakeholders (including executive managers who represented 'gatekeepers') were conducted in which both, the status quo of the created model, and the resulting visualization were discussed to gain insights on the business ecosystems.

3.4 Methodical Design Artefact: Modelling and Visualization Process

For both studies, we followed six principal steps to guide the modelling and visualization process of the business ecosystem, as illustrated in Figure 1.

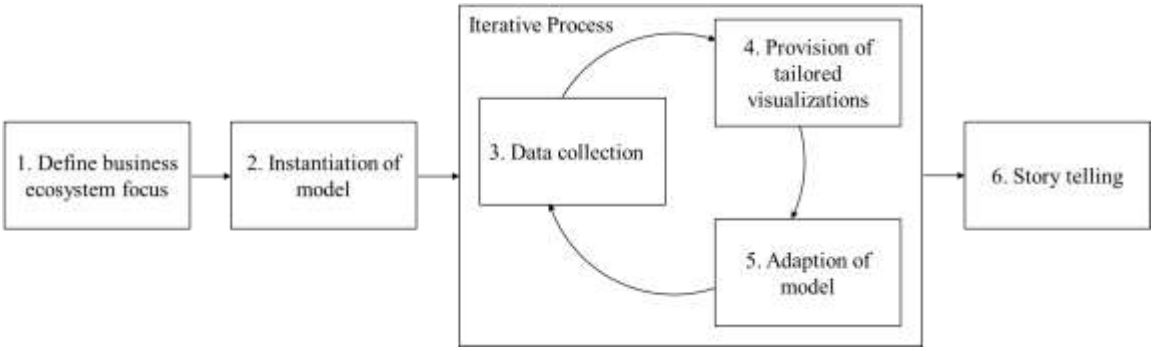

Figure 1. Modelling and visualization process (adapted from Basole et al., 2016)

In the first step, the *business ecosystem focus* is defined. Examples for a business ecosystem focus are ecosystems established all around a technology platform, an ecosystem of a specific market exploiting specific digital technologies (as e.g., in Sako, 2018) or ecosystems that emerge around one focal firm.

In the second step, *model instantiation*, initial models are created for two types of models, data and view model. Within the *data model* instantiation, the relevant entities of the ecosystem are defined, including attributes describing them. In addition, relation types between identified entities are preliminarily set. For the *view model*, the type of visualization including the specifications for this visualization are established. To ensure tailored visualizations in a later phase of the process, we have recognized that several stakeholders need to be involved into collecting the requirements for both types of models already in this early model instantiation phase.

In the next phase, an iterative process consisting of three steps follows: The *data collection* step gathers data about the ecosystem according to the specified data model; tailored visualizations need to be provided according to the defined view model; and feedback collected from involved stakeholders might lead to adaptions of the models. Ideally, this three-step process

is conducted iteratively until the collected data and the tailored visualization fulfil the stakeholders' requirements and needs. In our case studies, the iteration was conducted a limited number of times to the extent that satisfactory levels of informative value and validity of the models were achieved.

In the final process step, the created visualizations are used to extract knowledge about the ecosystem in form of a "story told", which contributes to a better understanding of the ecosystem in focus.

In both studies we deployed the collaborative work system *BEEx* to instantiate business ecosystem models. That is why for both studies prior to the actual modelling workshops, a dedicated workshop to explain the system was conducted, explaining the concept of data and view model and the system's capacity to adapt in run-time. Within these workshops, the aims for both studies were set; firstly, realising an instance of the business ecosystem model and secondly, learning to deploy the system for adapting the ecosystem model by following the described process.

Preliminary to starting the process, each stakeholder received a dedicated user identity. This allowed us to track model changes and who had carried them out; thus making the adaptations transparent. It also allowed us to identify particular contributions of the different stakeholders involved in addition to the workshops' observations. We consequently identified roles participants assumed in group model building across the different process steps as well as their influence on the modelling results; we will further detail these roles during our analysis.

3.5 Technological Design Artefact: Business Ecosystem Explorer (*BEEx*)

3.5.1 The Hybrid Wiki Approach to Collaborative Work

In order to cope with the requirements originating from the dynamics of business ecosystems, we deploy an *agile framework for modelling ecosystems*. This framework rests on the *Hybrid Wiki* approach (Reschenhofer, Bhat, Hernandez-Mendez, & Matthes, 2016) and has been implemented as an integrated, adaptive, collaborative work system that serves as application development platform and contains features for data management as well as collaboration and decision support. This system supports adaptation of both the model and its instances at runtime as carried out by stakeholders and ecosystem experts, i.e., users without programming knowledge or skills. It allows to track all model changes back to the user responsible and the time of change. To create the business ecosystem model within this system, we use the *Hybrid Wiki metamodel* (Reschenhofer, Bhat, Hernandez-Mendez, & Matthes, 2016) as visualized in Figure 2.

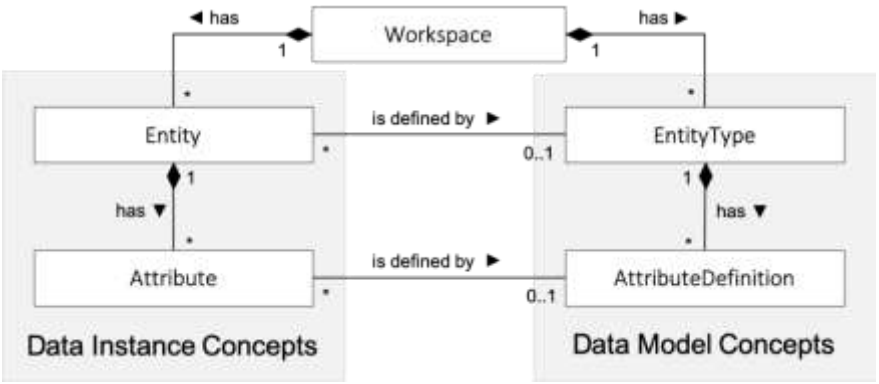

Figure 2. Hybrid Wiki meta-model (adapted from Reschenhofer (2017))

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, 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. 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.

3.5.2 Business Ecosystem Explorer Model

The agile framework relies on two types of models,

(a) *ecosystem data model*, and

(b) *ecosystem view model*,

each with respective features for instantiation and adaptation. Both model types are encoded using the Hybrid Wiki metamodel.

The *data model* contains the `EntityTypes` of relevance for the business ecosystem in focus. The *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 visualization using a declarative language. The used system provides the feature of adapting the models at runtime. In case of changes in the data model, such as adding a category of entities, changing or deleting existing categories, the visualizations are updated at runtime.

3.5.3 Business Ecosystem Explorer Views

The agile framework currently consists of six views: a *landing page,* a *list of all entities, detail view* with company information, a *relation view,* a *visualization overview*, and several visualizations. For all views, a menu bar at the top of the web page provides links to the other views available.

We used this framework in our case studies to discuss the principal idea of business ecosystem modelling and visualization. At a later stage of the study, stakeholders of both enterprises used the framework to create their own company workspace and self-selected suitable visualizations.

4 Case Studies: Collaborative Business Ecosystem Modelling and Visualization

4.1 Study 1: Innovative Mobility Services Business Ecosystem

The first study of an automotive company took place over five months, from December 2017 to April 2018. Within the entire study time, overall, five representatives were involved; two of these five were active in the modelling workshops; the three others were involved in major decisions. The study comprised of 11 workshops, each lasting between 60 and 120 minutes. All workshops took place on enterprise premises using laptops, a whiteboard, and pen and paper.

4.1.1 Course of the Study

The definition of the business ecosystem focus was set prior to the first modelling workshop. Purpose of this study was to model and visualize a business ecosystem of *innovative mobility services*. The firm stakeholders were interested in a better understanding about which cities are providing innovative mobility services within their landscape of mobility offers, and which service might be relevant for a city currently allocating less mobility services overall. Also of interest was a better understanding of which service provider offers which mobility services and how well each service provider is interconnected with which city. Prior to the study, in order to inform ourselves about the study context, the research team had analysed the business ecosystem of focus in a rudimentary way. Here, information about the business ecosystem had been collected with help of stakeholders from several organizations and documented in an unstructured form. This information however had not been processed further; a tracking about who had included which information and who had accessed it in a later stage was not conducted, and no visualization had been created).

Within the first three modelling sessions (December and January), the initial data model was created. As *BEEx* provides the feature of model adaptation, the data model was continuously updated in the following.

In the subsequent two months, two company representatives documented the data collected within the company in the system, and enriched it with additional data. Also, company external data sources such as newspaper articles, news feeds and free-of-charge online databases were used. The data collection process was conducted manually by enterprise representatives and not supported by the research team. During this phase, four modelling workshops were conducted. Within these workshops, the involved researchers answered question about the usage of the system. In addition, inconsistencies of the model were addressed and resolved.

In three workshops in February and March, the view model was created, and the initial visualization type defined, a force layout view. This decision was taken after two months of business ecosystem data collection and modelling. In a dedicated workshop, the building blocks (marks, scales, and signals) of each visualization were discussed and aligned. After having prepared this aligned view model, the research team created the business ecosystem visualizations accordingly. The tailored views were presented and discussed in the following workshops end of March. Collecting the feedback, the visualizations were adapted and further discussed in two workshops in April.

The final workshop took place at the end of April. Besides the gatekeeper, two modellers, two researchers and two additional enterprise stakeholders participated. The results of the previous modelling workshops were presented: Besides the two force layout views (Figure 3), a list view of all entities, a detailed view for each entity and one additional force layout view were presented and discussed. The feedback of the gatekeeper and additional modeller regarding the view model were incorporated immediately.

4.1.2 Data and View Model

The Hybrid Wiki metamodel was used to set up the data and view model. After the first data model creation workshop, the data model consisted of six `EntityTypes` and eight `AttributeDefinitions`. In the following session, the data model grew to finally eight `EntityTypes` and 26 `AttributeDefinitions`, a greater increase on the attribute level

than on the entity level. As `Entities` of the ecosystem, the modellers created *cities, organizations* (e.g., services providers such as automotive OEMs), *mobility services* and *mobility related projects. Mobility services* for instance comprised car sharing, bike sharing, ride sharing and others. The view model consisted of the three `Entities` describing the three force layouts. The three visualizations as depicted Figure 3 are described in the following.

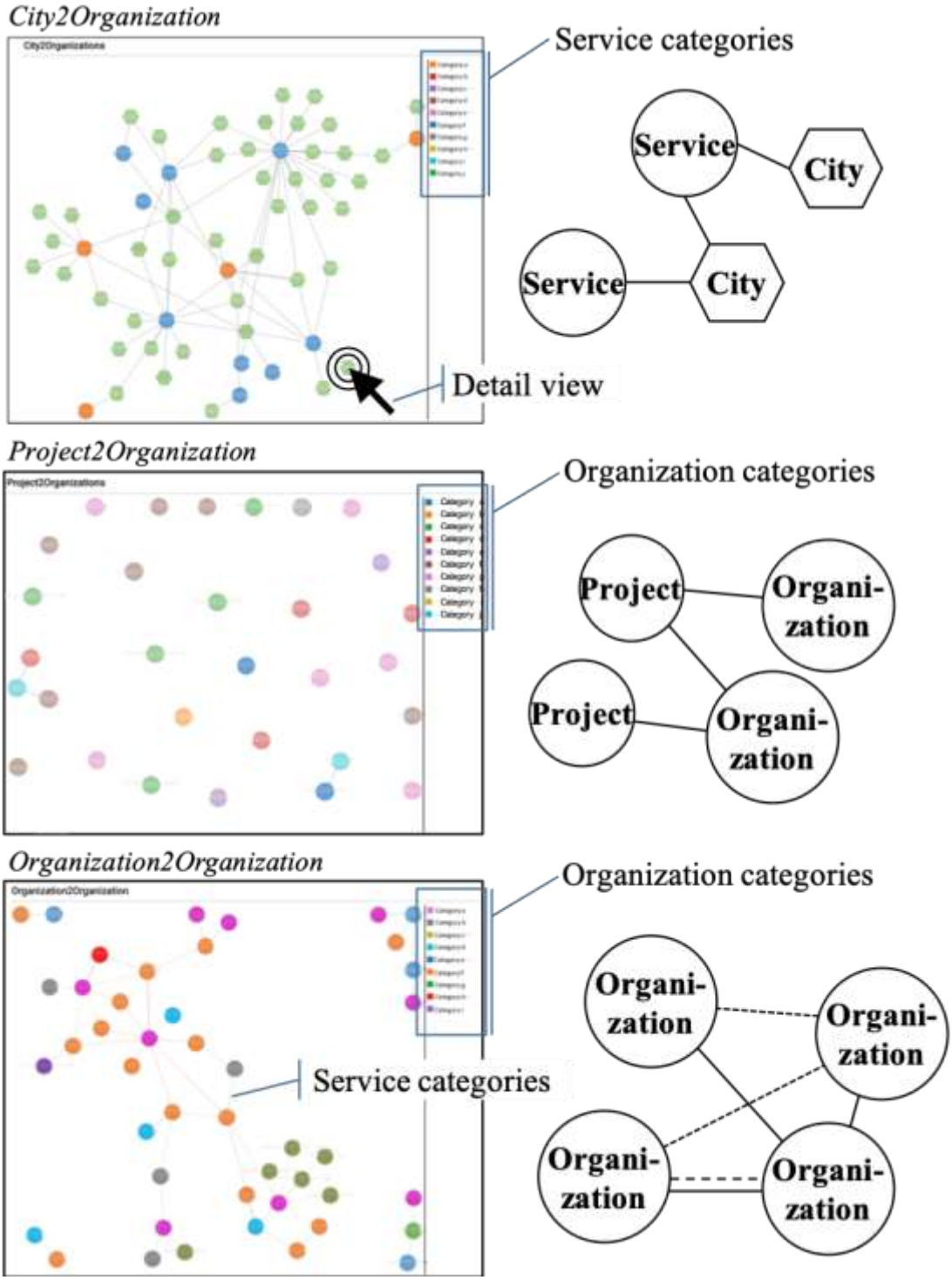

Figure 3. The three visualizations created in the first study. Due to anonymization requirements, the entity names and categories are blurred.

4.1.3 Created Business Ecosystem Visualizations

The first visualization, *City2Organization*, shows the network of cities and organizations and addresses the first two points of interest for the business ecosystem modelling, i.e., which cities are providing innovative mobility services within their mobility service landscape, and which service might be interesting to offer for a city allocating fewer mobility services currently. The visualization was specified to display cities as hexagons and organizations as circles.

For the second visualization, *Project2Organization*, the network of projects and organizations is shown; the shape of nodes is identical for projects and organizations.

In the third force layout, *Organization2Organization*, organizations and their relations are displayed. In this visualization, the relations are color-coded as well, as this was a request by one company representative. A corresponding legend was not implemented in this session.

For all three force layouts, the organization category is displayed using color-coded nodes as explained in the legends on the right sides of each visualization. All three visualizations provide interactive features. Clicking on a specific node directs the user to a view providing detail information about the respective entity.

4.1.4 Roles of the Collaborative Process

We validated four roles in this study: facilitator, modeller, recorder and gatekeeper. The gatekeeper was the most prominent participant in the beginning of the study. She decided on the business ecosystem focus and assigned stakeholders to participate in the modelling sessions. Within the second process step, one company representative established herself as the facilitator. She paid constant attention to the group process. She also took the lead in organizing all following modelling sessions. The facilitator was also the leading contributor in implementing existing data, enriching it with external data sources and thereby acting as a modeller especially between workshops. During this final workshop, she again took the lead explaining the results and the outcome. The researchers present in the workshops fulfilled both the modeller and recorder role by documenting each workshop in form of a written report.

4.2 Study 2: Publishing Company Business Ecosystem

The second study was conducted in cooperation with a publishing company. The study took place over six months, from February to August 2018. Overall, six enterprise representatives participated in the study in seven workshops, each lasting between 90 and 120 minutes. All seven workshops took place on the enterprise premises using laptops, a whiteboard, and pen and paper.

4.2.1 Course of the Study

Within the first workshop in February, the focus of the business ecosystem was set: modelling of a publishing business ecosystem, located in Germany, with regard to key persons, publishing landscape and the services offered and consumed. Besides identifying the ecosystem focus, previous activities and relevant additional stakeholder to involve were discussed. Information about the ecosystem in focus had not yet been collected or analysed and the ecosystem not yet modelled. A group of potentially relevant stakeholders to contribute to the modelling process were identified.

In the next two workshops, the ecosystem data model was discussed and defined, whereby the second workshop focused on enriching the model through the implementation of attribute definitions.

During a workshop in April, the ecosystem view model including the building blocks was initially discussed and determined. The study participants chose two force layout visualizations: one for the service landscape and the other for the key person network. At the beginning of May, the framework including two visualizations was provided by the researchers using the data collected in the collaborative work system. Both, company internal data sources but also news articles were used to collect relevant business ecosystem information. The data was entered mostly during the workshop sessions. In the following workshops, in which the prototype was demonstrated each time, the business ecosystem model was iteratively adapted. Therefore, five additional company representatives were included in two workshops in May to discuss the utility of the prototype and to provide feedback. Two more workshops took place in July for adapting the business ecosystem model further together with the study participants. The final workshop was held in August. Besides the core team, three additional company representatives participated who had already participated occasionally earlier. The study results and potential next steps were discussed.

4.2.2 Data and View Model

Within the study, both data and view model were created. After the first data model creation workshop, three `EntityTypes` with seven `AttributeDefinitions` were defined. At the end of the study, the final data model consisted of nine `EntityTypes`. These `EntityTypes` included 24 `AttributeDefinitions`. The data model evolved during the modelling process, especially on the attribute level and during the initial phase of the project. For the data model, ecosystem `Entities` such as key persons, publisher, and publishing groups were identified, including relation types such as the role of the person within the ecosystem and type of service. After the tool was provided, the data model on the entity level stayed the same. The ecosystem view model consisted of the two entities covering the visualizations displayed in Figure 4. After the view model was aligned upon, only one specification changed: the relation type *Berichtswesen* (German for 'reporting system') was adapted as it is a directed relation. This relation type is not displayed as a straight line connecting two ecosystem entities but through an arrow. Both visualizations are force layouts targeting to tell different stories about the company's business ecosystem.

4.2.3 Created Business Ecosystem Visualizations

In the first visualization (left hand in Figure 4), key individuals of the publishing area in Germany are visualized with their professional relations to publishers. The links are color-coded according to the roles occupied by identified key stakeholders of the ecosystem, which are explained in the legend in the top left corner. In addition, the structure of the relations provides insight if the role is executed currently, has been performed in the past, or will be established in the future. The legend of the structure is located in the top right corner. Both legends provide filter options to select a specific role of interest, like CEO, or status of employment, like current. When clicking on any entity, the user is directed to the collaborative work system and the according page in the workspace.

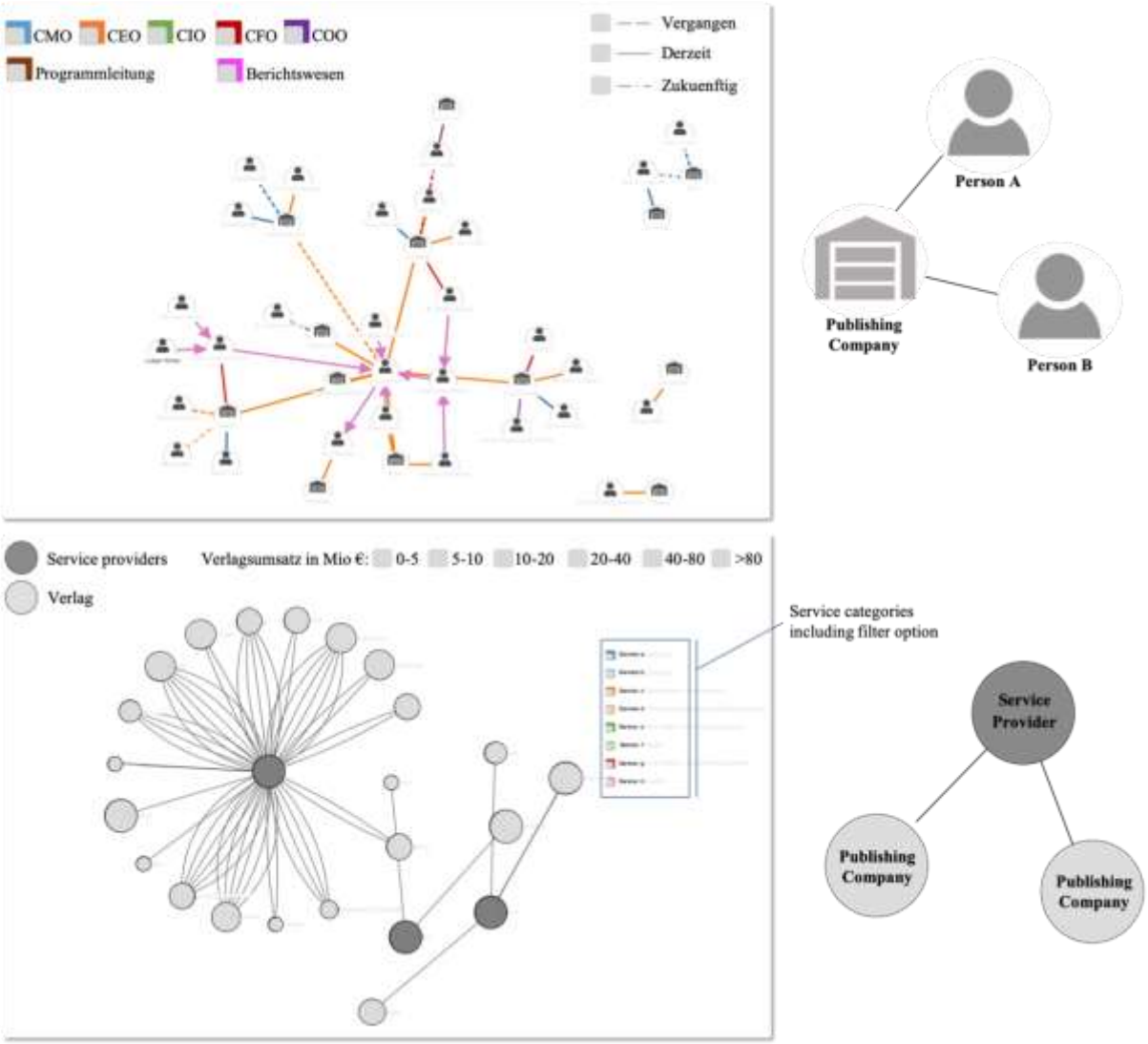

Figure 4. Two visualizations created in the second study. Due to anonymization requirements, the entity names and categories are blurred.

The second visualization displays publishing-related IT services provided within the industry. Dark grey nodes display service providers and lighter nodes publishers. The services provided are listed in the legend on the right. The visualization offers the interactive feature of showing the color-coded relations when hovering over any node. The node size of the publishing companies is set accordingly to their last year's business turnover as explained in the legend in the top right corner, whereas the size of the service providers is fixed. Again, both the turnover and the provided service legend provide filter options to select only publishers with a specific turnover or display only chosen services. When clicking on any node, the user is directed to the dedicated page in the system.

4.2.4 Roles of the Collaborative Process

Similar to the first study, we could validate four roles in this study: facilitator, modeller, recorder and gatekeeper. Within this study, the composition of the modelling groups changed within the study period. All participants who actively modelled participated in the pre-study workshop and thus were familiar with the *BEEx* system and the study aim. For all workshops, the group consisted of at least three participants. Already in the first workshop, one of the

company's representatives positioned herself as the facilitator. She kept this role over the entire study period and participated in all workshops. The facilitator also actively participated in the modelling as such but acted as decision maker and discussion leader. One example is the decision to use a force layout. The gatekeeper only participated twice in workshops in May and thus was identified at a late state of the process. Even though she had not been involved in previous workshops, her opinion and feedback to the provided and discussed visualizations were high prioritized by the facilitator. The researcher present in the workshops filled the role of the recorder and documented each workshop in form of a written report.

5 Cross-case Analysis and Discussion

Even though in both studies different topics and ecosystem models have been instantiated, we can draw some cross-case conclusions. Following Patton (2001) who defines lessons learned as the knowledge which is derived from the screening of a situation and which can be applied in similar situations in the future, we will present our finding and lessons learned of both studies.

5.1 Availability of Information about the Business Ecosystem

While the challenge of ecosystem data collection is not new (Basole et al., 2015), in both studies, the collection of information about the business ecosystem turned out to be more challenging than expected by the study participants. Especially in the first study, this constituted a reason for why the force layout visualization of organizations and their involvement in projects was rather neglected and the focus oriented towards the other two visualizations. A possible measure to improve ecosystem data collection could be using Internet data sources as an initial starting point for ecosystem modelling. We found that providing visualizations can point ecosystem stakeholders towards ecosystem information that is currently insufficient or missing, and can guide them towards novel information sources.

5.2 Evolution of the Data Model

In both case studies, we noticed that the data model evolved rather on the `AttributeType` level than on the `EntityType` level. That means, the `Entities` visualized remained nearly untouched whereby for all `Entities` the `Attributes` changed during the modelling process. In our opinion, this is due to the user being accustomed to the provided visualization and is thus less willing to change it. A change of the `Attribute`, which might also include adding or deleting an `Attribute`, does not involve changes of the force layout view. Furthermore, as the `Attributes` can be defined as mandatory or not, the user is free to add `Attributes` for specific `Entities` that are not available for others.

5.3 Expertise of Modelling Participants

Comparing both studies, we noticed that the knowledge workshop participants bring into the project, has a great influence on the achieved results. The modellers involved in the first study were less experienced with modelling activities as such. One consequence was that more time was spent on the data and view model creation and thus resulted in receiving the implemented interactive visualizations at a later point within the process. To address this, we recommend an additional workshop prior to the study period focussing on how to create a model. Our pre-study workshop solely focused on explaining the existing framework and the data and view model in use, but did not exercise the active participation of study participants.

5.4 Maintaining Motivation During the Modelling Process

Especially in the first study, we noticed a decrease in motivation during the data and view model creation phase. As described above, the study participants—including the facilitator—were unfamiliar with modelling activities. Thus, reaching the fourth process step took longer than expected by the company representatives. This holds especially true, as the predefined outcome of the study was an instance of the *BEEx* system including tailored interactive visualizations.

5.5 Importance to Provide Visualizations

The aforementioned findings lead us to conclude that the visualizations play a crucial role in the *perceived success* of the modelling process. We noticed within both studies that as soon as the interactive visualizations were provided with the additional feature of adapting changes to the data model and the data collected in run-time, contributed heavily to motivate the participants to collect and implement data.

5.6 Story Telling

As for both studies the focus was on the instantiation of the ecosystem model, the provided visualizations can be considered as early visualizations of the ecosystems. Within the studies, this process step was rather used to present the results of the study to the gatekeeper.

5.7 Collaborative Modelling

In both studies, several stakeholders were included in the modelling process. During the workshops, all participants contributed as modellers. Between the workshops, the overall contribution decreased, and only key team members—those we identified as facilitators—continued collecting and implementing data. Changes of the model were only implemented during the workshops, which might be due to the still rather unfamiliar framework in use. We recognized a lively discussion during the workshops, implying the relevance of managing the business ecosystem model in focus. Overall, we identified four distinct roles within both studies: The facilitator, the modeller, the recorder and the gatekeeper. As we conducted this process of instantiating a business ecosystem model first time, we assert that a process coach was missing.

6 Conclusion

We have conducted two Action Design Research case studies focused on collaborative approaches for modelling and visualizing business ecosystems. We report on the insights gained with regard to challenges that occur in the process, and discuss how model-driven approaches help addressing these challenges.

The generic modelling and visualization process we have instantiated (Figure 1) and the deployed collaborative work system, *BEEx*, support several stakeholders and roles to collaboratively contribute to the instantiation of a business ecosystem model. The process consists of six steps, namely, defining the business ecosystem in focus, instantiating both data and view model, collecting relevant data, providing tailored visualizations, obtaining feedback, which is fed into the iteration process of the two preceding steps, and finally, story-telling. We report in detail about the progress of our studies, the involvement of participants and conclude with findings and lessons learned.

A noticeable limitation of the presented work is the manual implementation of data, which is a time-consuming and tedious work. As visualizations are data-driven, business ecosystem visualizations in general heavily rely on the availability and quality of data. Complementing the manual data collection with (semi-) automated data extraction processes, such as provided by Natural Language Processing, could contribute to the enhanced availability of data and thus to richer visualizations, leading to better options for extracting knowledge. Regarding data quality, approaches towards data governance in the business ecosystem context in general as well as in our studies are missing; we envision the facilitator being a good starting point for addressing such a task. In addition, with respect to establish ecosystem modelling as a continuous task in an enterprise's strategy processes, we envision the iterative process steps to be conducted repeatedly, which would lead to data enrichment and potential inclusion of additional stakeholders within the company.

As a major challenge for ecosystem modelling, we recognize the right balance between early-on provision of tailored visualizations and following the process procedure. As our focus was on establishing a shared language within the modelling process, we provided visualizations only after aligning data and view model, which lead to a motivational decrease during the study. Nevertheless, we offer the presented process as a reference to organizations interested in modelling their business ecosystem. We hope our insights inform fellow researchers about the challenges associated with collaborative approaches for modelling and visualizing business ecosystems.

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