Visualizing Business Ecosystems: Results of a Systematic Mapping Study

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Abstract: Researchers and practitioners increasingly recognize the relevance of the complex business environment in which companies develop, produce, and distribute their services and products, which we refer to as business ecosystems. In scientific research, the characteristics of business ecosystems, including the changing relations between ecosystem entities, are often visualized. We conducted a systematic mapping study analyzing overall 136 papers to identify types of visualizations used in the business ecosystem context. We provide an overview of 17 visualization types and their frequency of application in scientific literature. In addition, we collected visualization tool requirements, which we enriched with our own experience visualizing business ecosystems with practitioners, leading to overall nine tool requirements.

1 INTRODUCTION

Business ecosystems have gained researchers' and practitioners' attention (Guittard et al., 2015; Bosch, 2016) as companies innovate, develop, produce and distribute their services and products in a complex business environment, which we refer to as business ecosystem. Thus, a business ecosystem extends the classic supply chain, consisting of suppliers and customer, by also including other entities within the business environment of the enterprise. It describes the holistic environment of a company covering current and potential future business partners, customers, suppliers, competitors, regulatory institutions, and innovative start-ups. As continuously entities enter and leave the ecosystem it exhibits a high dynamic (Peltoniemi and Vuori, 2004).

In scientific literature, various types of business ecosystems are presented and discussed, such as innovation ecosystem (Adner and Kapoor, 2010), platform business ecosystems (Toivanen et al., 2015), or software ecosystems (van den Berk et al., 2010), describing the roles within (Moore, 1996; Iansiti and Levien, 2004) or the structure of (Visnjic et al., 2016) the ecosystem in focus. To illustrate these ecosystem characteristics authors use visualizations, which are often static. In parallel, to provide insights about the entities and their relations within the business ecosystem, interactive visualizations have been proven to support decision makers in their ecosystem related tasks (Basole et al., 2016; Huhtamaki and Rubens, 2016; Evans and Basole, 2016). Thereby, visualizations can help to derive value from ecosystem data, e.g., in order to spot anomalies, identify keystone and niche players of the ecosystem, or recognize change patterns and trends (Vartak et al., 2016).

Our contribution in this paper is two-fold as it involves the description of 1) used visualizations within business ecosystem literature and 2) synthesized tool requirements for visualizing business ecosystems. We draw on results gained through a systematic mapping study we conducted. Even though, we identified four existing literature reviews addressing business ecosystems, none targeted visualizations of these.

2 RESEARCH BACKGROUND

2.1 Business Ecosystem

James Moore introduced business ecosystems in the mid-1990s, defining them as a collection of interacting companies (Moore, 1996). He presented a framework to describe the interplay between the core business, extended business, and business ecosystem of a company (Fig. 2 e). Thereby, the life cycle of a business ecosystem consists of four phases, namely birth/pioneering, expansion, leadership/authority, and self-renewal or death (Moore, 1993, 1996). The first phase denotes the idea development. In the second phase, the idea is brought to the markets, followed by the attempt to gain leadership. When the third phase is accomplished, there are two possible outcomes: ei-

ther the organizations withing the ecosystem are able to constantly innovate, leading to the survival of their ecosystem; or they fail to do so, wherefore the ecosystem dies. Each evolutionary stage comprises cooperative and competitive challenges in order to maintain a healthy ecosystem along each phase. The initial definition was enriched describing the role of companies 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 business success and failure of companies active within the business ecosystem. Furthermore, business ecosystems constantly evolve, exhibiting a dynamic structure (Peltoniemi and Vuori, 2004), with not only companies but also human actors, entering and leaving the ecosystem, which "are interconnected through a complex, global network of relationships" (Basole et al., 2015).

2.2 Business Ecosystem Visualization

Visualizations of business ecosystems have proven to enable ecosystem stakeholders to take better-informed decisions (Basole et al., 2016; Huhtamaki and Rubens, 2016; Evans and Basole, 2016). Research addressing ecosystem visualizations has used data sets collected from commercial databases on business and economic data or drawn from social or business media (Basole et al., 2012, 2015).

Basole et al. (2013) developed and presented the tool *dotlink360* to support ecosystem stakeholders in understanding interfirm relationships in business ecosystems by providing interactive visualizations. The main goal was to visualize the mobile ecosystem, with entities such as mobile network providers, platform providers, or device manufacturers. It consists of six visualizations: a scrollable list (Fig. 2 a); composition view to display detailed company information; a temporal view depicting when relationships were formed and how active an entity is in forming relations; a geographical view displaying the location of the entities' headquarters (Fig. 2 c); a segment view, which is a mixture of a chord diagram and a network; and a scatter plot (Fig. 2 i) to visualize financial metrics.

Like dotlink360, *ecoxight* was developed by Basole et al. (2018). It draws on data from ProgrammableWeb and Crunchbase to depict the API (application programming interface) ecosystem. Five distinct views are presented: a path view (a node-link diagram), a category view (a combination of a chord diagram, and a network); a geography view; ScatterNet view (a scatter plot); and a temporal view.

The tool *Business Ecosystem Explorer (BEEx)* was developed to model and visualize the smart city business ecosystem (Faber et al., 2018a). The tool applies a wiki-based approach for the ecosystem data collection and offers collaborative modeling features (Faber, 2017). It includes five distinct views: a list (Fig. 2 a), an adjacency matrix (Fig. 2 p), a force layout (Fig. 2 q), a treemap (Fig. 2 m) and a chord diagram (Fig. 2 n). In addition, a detailed overview for each entity is available.

3 RELATED WORK

As business ecosystems gained relevance, this work is not the first literature review addressing business ecosystem related research. In the following, we briefly summarize four existing literature reviews we identified during our systematic mapping study.

Mäkinen and Dedehayir (2012) published a literature review targeting business ecosystem evolution and strategic considerations. Analyzing 68 papers, they discuss (i) business ecosystem members and their roles, (ii) factors that influence the evolution of business ecosystems, (iii) the dynamics of ecosystem change, and (iv) the strategic considerations of firms positioned in ecosystems. de Vasconceles Gomes et al. (2016) focused their literature review on innovation ecosystems by analyzing 193 articles. They highlight the most influential papers, and discuss the innovation ecosystem concept and its variations. Finally, they identified six related research streams: industry platform x innovation ecosystem; innovation ecosystem strategy, strategic management, value creation and business model; innovation management; managing partners; the innovation ecosystem life cycle; and innovation ecosystem and new venture creation. Järvi and Kortelainen (2017) describe results of their literature review conducted in November 2014. They analyzed overall 72 articles, identifying three units of analysis: the individual actor (typically a firm), the relationship between the actors, and the ecosystem. Thereby, the individual actor can play a variety of roles, such as customer, delivery channel, seller of complementary products and services, supplier, or policy maker etc, which occupy different positions in ecosystems, such as a hub or niche position. As relationships in the ecosystem they identify the interaction; interdependence and substitution; and the relationship between the focal firm and the complementor; and finally for the ecosystem with its collective and collaborative value creation and discuss the competition between ecosystems; the ecosystem clockspeed; ecosystem life cycle; network structure; and transformation from supply or value. In a recent

study, Scaringella and Radziwon (2018) analyzed 104 articles addressing ecosystems. They discuss the four main types of ecosystems, namely business, innovation, entrepreneurial, and knowledge; providing an overview about related theories from the territorial approach and identify invariants between both research directions. In addition, they propose a research framework based on their comparison as a basis for future empirical research.

None of these literature reviews addresses the visualizations of business ecosystems, which we address with the here presented results.

4 RESEARCH DESIGN

For this research, we conducted a systematic mapping study, which is a specific form of a literature review (Kitchenham et al., 2011; Petersen et al., 2008). It "aims at reviewing a relatively broad topic by identifying, analyzing, and structuring the goals, methods, and contents of conducted primary studies. Therefore, the state-of-the-art research, research gaps, or matured sub-areas can be identified and explicated" (Wendler, 2012, p. 1318). The overall research process consists of eight process steps and is visualized in Figure 1.

4.1 Research Method and Research Questions

This study aimed to obtain an overview of used visualizations to describe characteristics of business ecosystems and already existing tool requirements to visualize business ecosystem entities and their relations. In a first step, we defined two research questions as the guiding foundation for the results presented here:

RQ1. What visualizations are used in literature to illustrate business ecosystems and the concept?

RQ2. Which requirements towards business ecosystem visualization tools have been formulated?

The rational of RQ1 is to identify visualization types used within business ecosystem research. RQ2 aims are synthesizing existing tool requirements to provide visualizations targeting the dynamic changes of business ecosystem entities and their relations.

4.2 Search Process

In the following, we briefly describe the conducted steps of searching, selecting, and analyzing existing scientific literature in the mapping study.

Selection of Data Sources and Search Strategy. For the selection of suitable databases, we identified relevant research areas related to business ecosystems: computer science, information systems, and management theory. The conducted mapping study was based on electronic databases. An extensive selection of databases was the first step in fulfilling the research aim of a comprehensive overview about research in business ecosystems. We selected the databases Association for Computing Machinery (ACM), Electrical and Electronics Engineers (IEEE), ScienceDirect, Scopus, SpringerLink, and Web of Science as these databases cover publications of the previously identified research domains. We conducted the search in September and October 2018, using the search string *business ecosystem*. Within the initial search only the titles, abstracts, and keywords were analyzed. If at least one of these three contained the term business ecosystem, the paper was considered. This resulted in overall 1,842 papers after the initial search.

Inclusion and Exclusion Criteria. In the next process steps, relevant articles were entered in the "pool of papers" (Wendler, 2012) and irrelevant paper were excluded. Papers were included in case they were written in English and the scope was related to business ecosystems. We excluded papers with a lack of business focus, i.e., interaction of multiple actors crossing industries, but rather describing technical aspects or architectural descriptions of ecosystems. In order to maintain high quality standards, results with a "notice of violation"- or "notice of retraction"-note were excluded as well. After reading title, abstract, and keywords, 382 articles were labeled as potentially relevant, after which 124 duplicates were removed, leaving 258 papers. For these remaining papers, a content mapping matrix was created, consisting of the business ecosystem characteristics: definition, roles, phases, types, visualizations, applications, and examples (with BE as abbreviation for business ecosystem). These characteristics are:

BE Definition. Either a new definition of business ecosystem is established, it adds to an existing definition, sums up different definitions, or compares existing definitions (58 papers).

BE Roles. The different roles ecosystem actors incorporate are described, a new descriptive metaphor is established for these roles or different roles are compared (70 papers).

BE Phases. The paper establishes a business ecosystem life cycle, describes at least one state of a business ecosystem, or it compares different life cycle models (29 papers).

BE Types. The paper describes at least one type of business ecosystem or compares multiple types (42

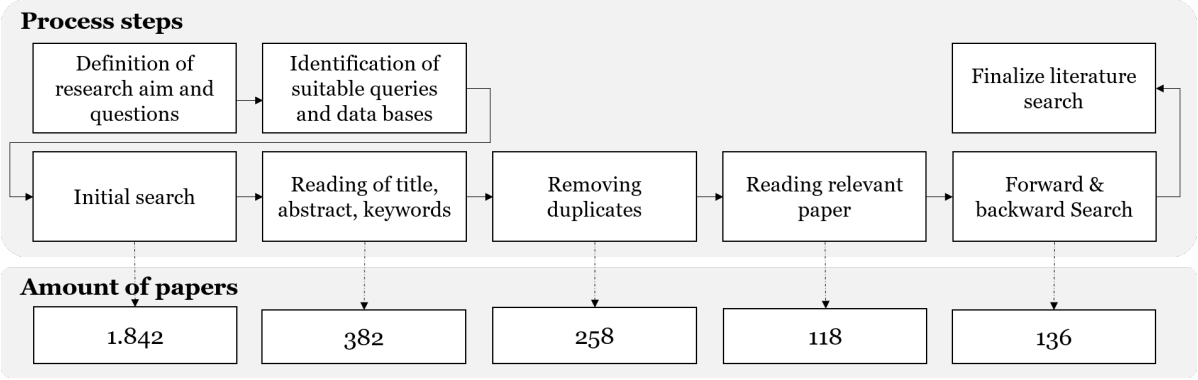

Figure 1: Search process (following (Wendler, 2012)).

papers).

BE Visualization. The article contains at least one business ecosystem visualization, describes how a business ecosystem can be visualized, develops or uses a modeling or visualization tool (43 papers).

BE Application. Applications of the business ecosystem concept both in research and practice (58 papers).

BE Example. Paper demonstrating a specific example of a business ecosystem in a real world context, e.g., for Walmart or Alibaba (49 papers).

Applying the mapping matrix led to 118 relevant papers. Last, forward and backward citation search (Webster and Watson, 2002) was applied on these records, through which we identified 18 additional papers. Thus, overall we analyzed 136 paper in our systematic mapping study. Due to the page limitation, we will only present here results related to used business ecosystem visualizations and requirements towards business ecosystem visualizations and a tool-support of the latter.

5 BUSINESS ECOSYSTEM VISUALIZATIONS

Within our mapping study, we identified 43 records, which incorporate business ecosystem visualizations. These either use visualizations to describe a business ecosystem, or discuss how a business ecosystem can be visualized. All visualization related records include at least one visual to depict an actual, simplified, or sample business ecosystem. 42 results include network visualizations such as node networks (Fig. 2 q), directed networks (Fig. 2 o), chord diagrams (Fig. 2 n), or matrices (Fig. 2 p). Multi-dimensional visualizations, including bar charts (Fig. 2 f), line charts (Fig. 2 h), or adaptations of Moore's (1996) framework (Fig. 2 e), tree visualizations, such as tree maps (Fig. 2 m) or variations of the sunburst diagram (Fig. 2 l), and 1-dimensional lists (Fig. 2 a) were mentioned in 24, 9, or 7 records respectively. Timelines (Fig. 2 d) were the only temporal visualization used, whereas connection map (Fig. 2 b) and dot map (Fig. 2 c) were the only 2-dimensional visualizations.

6 TOOL REQUIREMENTS FOR BUSINESS ECOSYSTEM VISUALIZATIONS

Three of the 43 identified papers discuss requirements for suitable visualization tools: twice Basole et al. (2013, 2018); and Hernandez-Mendez et al. (2017). All three papers aimed at developing a visualization tool targeting business ecosystems. In the following we list, describe, and synthezise these requirements into a single set of requirements, which we enrich with requirements identified during two case studies we conducted.

6.1 Requirements in Business Ecosystem Literature

Basole et al. (2013) presented their tool, *dotlink360*, in their 2013 paper. Prior to finalizing the tool, they set up the following requirements for visualizations and the tool developed, in which they incorporate the feedback of practitioners:

B13R1. Both top-down and bottom-up examination of an ecosystem are critical; thus providing flexible navigation between higher-level ecosystem overviews and individual details;

B13R2. Understanding interfirm connectivity, composition, and temporality is vital;

B13R3. Comparative perspectives drive insights so it is important to communicate multiple perspectives;

B13R4. Communicate agreement summaries first,

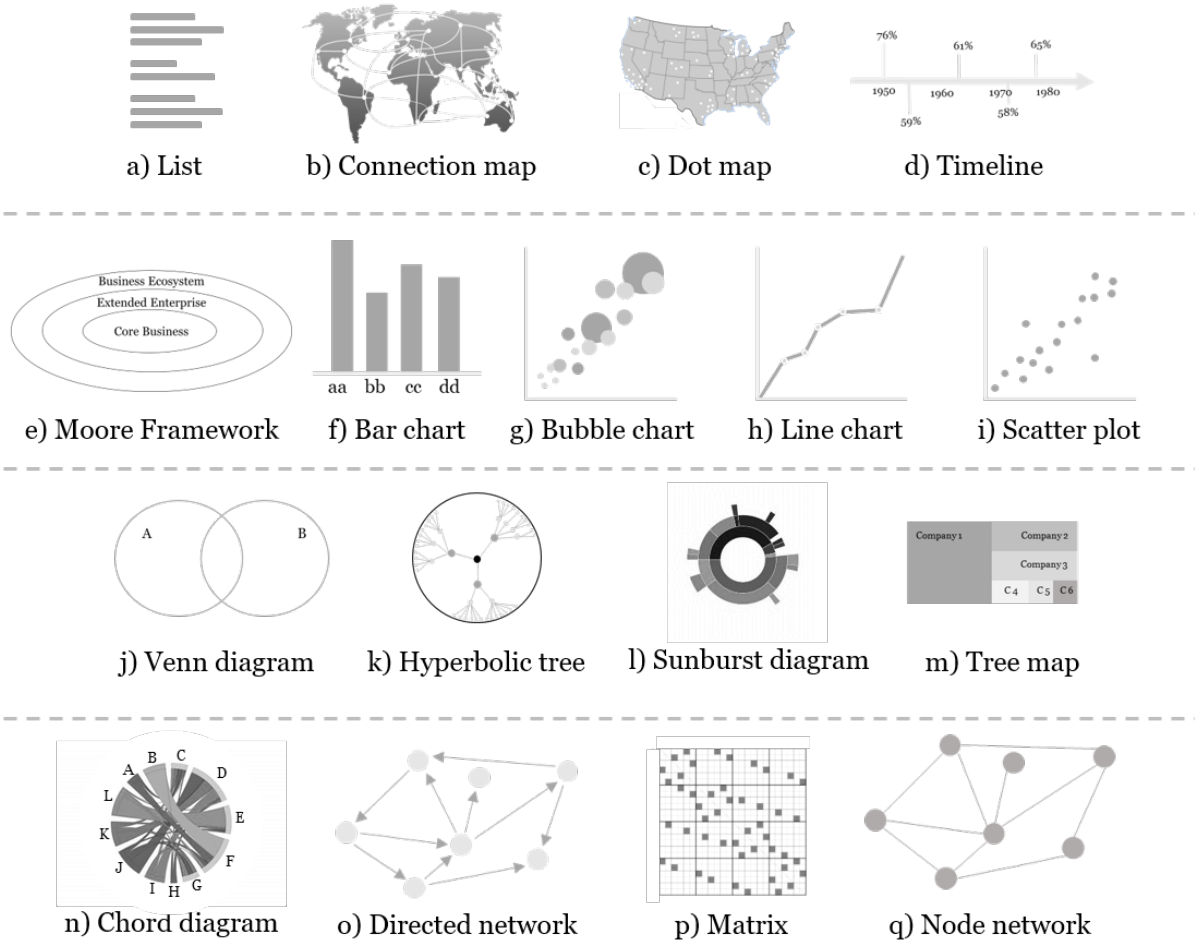

Figure 2: Used business ecosystem visualization types.

then details as desired; and

B13R5. Provide a familiar metaphor while supporting direct and prompt interaction, not complex queries and commands.

In 2018, Basole et al. (2018) presented a second tool, named *ecoxight*. Again, they defined five visualization requirements with the help of practitioners:

B18R1. Triangulated insights through application of multiple perspectives;

B18R2. Explore multiplex relationships through appropriate mechanisms;

B18R3. Understand temporal ecosystem dynamics, explore dynamic network;

B18R4. Facilitate multiple modes of inquiry with rich dynamic filtering and querying capabilities; and

B18R5. Easy-to-use and familiar design.

One year prior, Hernandez-Mendez et al. (2017) published a paper describing their visualization tool, the *Business Ecosystem Explorer (BEEx)*, including four requirements:

H17R1. Support semi- and non-structured underlying business ecosystem data;

H17R2. Ability to modify the business ecosystem model and visualizations at run-time;

H17R3. Provide role-based user interfaces for different stakeholder roles; and

H17R4. Must be supported by WEB-based technologies.

Park et al. (2016) presented a visual analytic system for the analysis of a supply chain management ecosystem and also identify three similar 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. However, as this paper targets specifically supply chain management, it was not covered in the results of our systematic mapping study.

Both Basole-papers (Basole et al., 2013, 2018) emphasized the role of multiple visualization approaches (B13R3 and B18R1). Basole et al. (2013) insist to include top-down as well as bottom-up examina-

tion, in order to be able to view the big picture as well as single entities and relations (B13R1). Additionally, Basole et al. (2018) address filtering and querying options to limit the information to those needed and facilitate searching for a particular information (B13R4). These requirements indicate the necessity to provide more than one visualization layout. All of the other requirements mentioned by Basole et al. (2013, 2018) are in light of the visualizations in particular rather than the tools. They relate to the three initial components of business ecosystems: the network, the relations, and the temporal dynamics. Finally, the temporal dynamics, or the evolution, of a business ecosystem, needs to be incorporated (B13R2, B16R3). As visualizations are data driven, a business ecosystem visualization tool should be able to deal with the variety of underlying ecosystem data. This data can be structured, semi-structured, or non-structured, depending on the used data source (H17R1). Being able to modify the visualization and the underlying model enables ecosystem stakeholders to adapt the business ecosystem model according to environmental changes (H17R2). Envisioning a team of ecosystem experts providing the ecosystem visualizations to non-technical ecosystem stakeholders, these should be addressed by the visualization tool through the provision of different user interfaces (H17R3). Finally, enabling the use of WEB-based technologies broadens the scope of usability (H17R4). In addition to these tool requirements, Basole et al. (2013, 2018) emphasize that the user interface should not be too complex (B13R5), but easy to use (B18R5) and in a familiar design (B13R5, B18R5).

6.2 Synthesized Visualization Criteria from Literature

After analyzing the identified requirements towards business ecosystem visualizations, we can synthesize them into overall seven requirements towards business ecosystem visualizations displaying ecosystem entities, their relations, the evolution of the ecosystem, and a tool enclosing these visualizations.

For the visualizations it is important, that the relation between ecosystem entities is depicted including describing characteristics of each relations. We refer to these describing characteristics as attributes.

Requirement 1. *Display the multiplex relations between the ecosystem entities and provide attributes describing these relations.*

In addition, for the visualization – as ecosystem data is large and heterogeneous (Basole et al., 2015), ranging from technology-related data about applied standards and platforms to use, to market information and legal regulations – it is important to allow users to filter, highlight, or mark specific parts of the visualized ecosystem, summarized as interactive features.

Requirement 2. *The provided visualization should comprise interactive features such as clicking, dragging, hovering, and filtering.*

As every visualization is limited in the insights it can offer, having multiple perspectives on business ecosystems allows practitioners to look at business ecosystems from different angles, set focuses where needed, and gain more insights.

Requirement 3. *Offer multiple perspectives on the whole ecosystem by providing multiple views and provide flexible navigation between these visualizations.*

As ecosystem entities continuously enter and leave the ecosystem, it is changing over time. Insights can be gained by visualizing the evolution of business ecosystems.

Requirement 4. *Depict the change of structure a business ecosystem undergoes over time.*

Basole et al. (2013, 2018) emphasized, in both papers, the usability of a business ecosystem visualization tool. In order to entitle even practitioners without technological experience to work with the business ecosystem visualizations, the tool should be easy to use.

Requirement 5. *Provide a familiar and easy-to-use user interface to display the visualization(s).*

Data comprising information about the business ecosystem can come 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. Thus, a tool visualizing business ecosystem data should allow different data formats to be included.

Requirement 6. *Support usage of semi- and non-structured underlying business ecosystem data.*

As ecosystems change dynamically, ecosystem stakeholders should be able to change the business ecosystem data model according to environmental changes – as new entities enter and leave the ecosystem, and existing relations are changed or new ones are added. This holds also true for the visualizations used: if ecosystem stakeholder requirements towards the provided visualizations change, the visualizations should be adaptable as well.

Requirement 7. *Allow the modification of the business ecosystem model and visualizations at run-time.*

We have deliberately excluded the requirement H17R4 because we do not want to assume a team of ecosystem experts to model the ecosystem in the background.

6.3 Practical Experiences Visualizing Business Ecosystem

In two case studies we conducted in the context of collaborative business ecosystem visualizations (Faber et al., 2018b), we gained insights relevant for tool requirements. In these studies, we focused on the collaborative aspect to model and visualize the business ecosystem within a design science project. Therefore, we propose to add the following tool requirements.
To include diverse aspects and perspectives of the business ecosystem in the modeling focus, it is important to involve groups of stakeholders with diverse skills and expertise in the modeling process. These stakeholders should be able to access the system separately, but then collaboratively update and adapt the business ecosystem data model according to occurring changes.
Requirement 8. *Multiple stakeholders with different roles and different kinds of expertise should be enabled to contribute to the collaborative instantiation and creation of the business ecosystem model.*
When ecosystem stakeholders model business ecosystems for the first time and existing models and tools are not available, it is unclear what information will be available with what accuracy and frequency. However, stakeholders should be given the freedom to model the ecosystem without a predefined structure as they see fit to answer and fulfill their ecosystem specific questions and tasks.
Requirement 9. *No structures of the business ecosystem models should be imposed. The model should be dynamically enriched with additional, not yet defined structure.*

7 DISCUSSION AND CONCLUSION

Using insights gained through a systematic mapping study, the contribution of this paper is two-fold: we provided an overview of applied visualizations to describe characteristics of business ecosystems in scientific literature. In addition, to provide the basis for a tool-support to visualize business ecosystems, we synthesized existing requirements of presented tools and supplemented these with insights we gained through a design science project applied in two case studies.

We present an overview of 17 visualization types practitioners and researchers interested in visualizing business ecosystems can pick from. Network visualizations are the most intuitive and most frequently applied visualizations for business ecosystems. Thereby, node networks are the most prominent, followed by directed networks. Also, we discuss nine tool requirements to visualize business ecosystems, as we synthesized existing requirements in scientific literature enriched with collaborative aspects to include various stakeholders in the business ecosystem modeling process.

A noticeable limitation of the presented work is the applied search string within the systematic mapping study. Additional search strings, such as *business network*, *business clusters* or *networked ecosystems* could have contributed to the results presented here. Nevertheless, as business ecosystems continuously gain more interest of researchers and practitioners, we believe that the presented results provide a baseline for both groups when visualizing business ecosystems or developing a tool to visualize ecosystems.

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