Tool-Supported Collaborative Modeling and Visualizations of Business Ecosystems

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1. INTRODUCTION

We present a business ecosystem visualization tool*, BEEx – Business Ecosystem Explorer*, in line with a report on original research results obtained during its development and prototypical use in several case studies. Our submission, while based on original and completed research, intends to present BEEx as demonstration of a new tool, rather than a "market-ready service," because several aspects in its application as Collective Intelligence instrument could so far not be addressed by our own (and other authors') research work.
The intended system use of BEEx rests on *crowd-based modelling and information provision* and intends to enable *collective decision making and problem-solving* in the business ecosystem context. This context may encompass *participatory approaches* for drafting of corporate ecosystem strategies, or for policy development by regional authorities and citizens, e.g., in the smart city context, among other uses. In this sense, we have applied BEEx in various case studies as *new visualization technology for making groups smarter*. In the following, we provide an overview of aspects concerning the use of BEEx in the business ecosystem context. We outline major elements of its architecture, functionality and visualization types implemented so far. Finally, we address the open questions linked to its 'ideal' use in business ecosystems, which we intend to address at the conference.
A recent open access paper that illustrates aspects of our work is available online [Faber et al. 2018b]. The system promotion website is available online at https://ecosystem-explorer.in.tum.de/#/ .

2. BUSINESS ECOSYSTEMS

Business ecosystems have gained interest from researchers and practitioners as companies as well as public organizations increasingly recognize the relevance of their complex business environment. This environment consists of all value creation activities related to development, production and distribution of services and products and comprises suppliers, manufacturers, customers, and entrepreneurs. Coping with the challenges and opening up the opportunities that arise in these business ecosystems is a reality for most companies nowadays [Peltoniemi and Vuori 2004]. The growing relevance of business ecosystems substantiates through the perceived *shift of the competitive environment from single companies and their supply chains towards ecosystems competing against each other* [Bosch 2016].
We define *business ecosystems as the holistic environment of an organization covering current and potential future business partners, such as customers, suppliers, competitors, regulatory institutions and innovative start-ups*. As such entities continuously enter and leave the ecosystem, or change their role within the ecosystem, ecosystems exhibit high dynamics. Peltoniemi and Vuori [2004] provide a comprehensive definition of business ecosystems that emphasizes this adaptive characteristic. Moore [1997] uses the metaphor of biological ecosystems as a basis for his initial definition of business ecosystems. Metaphorically, as in natural ecosystems, the economic success of an enterprise can therefore depend on the individual 'health' and capability to evolve with their business ecosystem. In the ecosystem, the participating companies as individuals adopt varying levels of influence on the overall health of the ecosystem, taking up roles as keystone or niche player [Iansiti and Levien 2004].

Because ecosystems potentially influence the economic success of businesses, enterprises increasingly realize the need to *analyze their business ecosystem*. Through continuous monitoring, changes within an enterprise's ecosystem might be identified and addressed through dedicated strategies or adaptations [Basole et al. 2016]. Enterprises aim to "learn what makes the environment tick" [Porter 1979] and improve or adapt one's own business activities accordingly.

However, analyzing business ecosystems is principally impossible for one single stakeholder to achieve because of the abundancy and complexity of processes and data that would need to be observed, recorded, documented or otherwise be made visible. This is why… we acclaim for an approach to use crowdsourcing of ecosystem-related data in order to create ecosystem models that can be exploited to learn about the ecosystem and to predict future developments [Morecroft and Sterman 1994] and that inform and configure shared platforms and infrastructures and as such become valuable for the entire ecosystem [Constantinides et al. 2018]. However, crowdsourcing approaches to model business ecosystems so far have not been implemented or observed in practice. (This section is an excerpt of a manuscript under review).

3. BUSINESS ECOSYSTEM VISUALIZATION

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 business ecosystems is often 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. (This section is an excerpt of [Faber et al. 2018a]).

4. BEEx – BUSINESS ECOSYSTEM EXPLORER

For the design of BEEx, our Visual Analytic System (VAS), we extend on a software engineering framework that technically resides upon the 'Hybrid Wiki' approach…, and which from a use perspective allows to follow an agile process to create and adapt the model that is used by the VAS to represent ecosystem entities and structures (…). This framework addresses the dynamic structure of business ecosystems as it supports the evolution of the model as well as its instances at runtime by stakeholders and ecosystem experts, i.e., users without programming knowledge or skills. We have implemented the framework as Business Ecosystem Explorer (BEEx) on basis of an existing integrated, adaptive, collaborative Hybrid Wiki system. The latter system not only serves as a Knowledge Management System (KMS) application development platform, including features necessary for collaboration, data management, and decision support, but which also implements other features such as tracing back changes to the responsible user, including the time and date the change was made. In our case studies, we have used its underlying Hybrid Wiki metamodel to create business ecosystem models.

BEEx allows configuring diverse types of visualizations (layouts). In our case studies, we used a declarative language to implement four layouts in order to visualize the collected data along the categories defined in the ecosystem data model: chord diagram, matrix, tree map, and force-directed layout. (For illustrations, please refer to the promotion website).

The visualizations provided by BEEx were tested across various case studies as for instance in context of corporate business ecosystem strategy development, and smart cities, to support the mobility business ecosystem stakeholders by providing informative value, and by stimulating reflection on the ecosystem in order to increase understanding of the ecosystem and improve related policy and business initiatives. In our case studies, we could validate the contributive nature of agile processes and involved roles to collaboratively manage and adapt the business ecosystem model. Data collection in order to create and populate ecosystem models is a critical issue, and we formulated three basic categories for identifying, assessing and selecting Internet data sources that are supposed to serve as a guideline for future modeling projects. We also tested view models for visualizing smart city mobility business ecosystems. (This section is an excerpt of [Faber et al. 2018b]).

5. OPEN QUESTIONS TO BE ADDRESSED AT THE CONFERENCE

(1) Is it reasonable to assume that professionals will provide knowledge about their business ecosystem and engage in modelling business ecosystem structures to populate models of a shared, community-wide system/service?

(2) How can data be obtained about the entities to be modelled, such as start-ups, firms, public entities and their relationships with each other? So far, an editorial team has collected such information. Can this process be transformed into a more wide-reaching community, maybe supported by open or closed professional social networks – or in cases of smart cities, crowd-based approaches?

(3) How can further data be included in an automated way, e.g., by linking peripheral data from IIoT systems in smart cities, or from business databases (such as Crunchbase)? How can this be accomplished without compromising intellectual property rights or data privacy rights of the legal entities and persons about whom data is collected?

(4) How could/should data governance be designed in order to ensure liabilities are with the appropriate stakeholders of such as system?

(5) What types of additional analyses, e.g., stemming from computational social science, could prove reasonable to enhance visualization towards recommendations or simulations?

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