Towards an Understanding of the Connected Mobility Ecosystem from a German Perspective

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Abstract: This paper presents a model of the connected mobility ecosystem, which contains a description of the associated industry. Although connected mobility is a topic of global relevance and interest, we analyzed the ecosystem from a Germany perspective due to Germany's strong history of automotive OEMs and suppliers. To gain a better understanding of the mobility ecosystem, we introduced a modified ego network visualization focusing on mobility services. This visualization guarantees an user-centred design analysis of the ecosystem and enables stakeholders to identify companies that are highly contributing in providing these services and rather passive contributors. Additionally, it allows ecosystem stakeholders to understand the complex collaborations of companies in providing mobility services. We plan to continue our work focusing on mobility scenarios addressing the needs and demands of mobility consumers.

1 INTRODUCTION

The enterprise's competitive battleground is shifting towards creation and contribution within the ecosystem in which the business exists (Bosch, 2016). This increases the relevance of modeling enterprises from a holistic point of view, which considers not only the company itself yet their business relationships, networks, and alliances (Kelly, 2015) with partners, suppliers, customers, and competitors (Bosch, 2016). Knowing and understanding the entire ecosystem could lead to the selection of strategy deciding about enterprise's success or failure.

Several approaches for modeling the business ecosystems are used in research. For example, the importance of digital business ecosystems for small and medium-sized enterprises (SME) in Europe is described in (Nachira, 2002). Whereas, Basole et al. focus on the visualization and understanding of dynamics of business ecosystems following a data-driven approach ((Basole and Karla, 2011), (Basole et al., 2015), (Iyer and Basole, 2016)).

As digitalization and its advancements has long reached the personal urban mobility and is transforming the mobility landscape (Henfridsson and Lindgren, 2005), it is also transforming the ecosystem for mobility. Digital technologies are continuously integrated in vehicles, traffic systems, and infrastructure (Mitchell, 2010), and are changing the mobility behavior of humans, especially in big cities. New phenomenon such as shared mobility, which includes car sharing, ridesharing, and bike sharing, and their corresponding sustainability business models, arise (Cohen and Kietzmann, 2014). Thereby, the digitization of mobility is often addressed with the term "connected mobility", to emphasize the interconnectedness between mobility consumers, vehicles, and traffic systems and infrastructure, both by industry (e.g., (Rossbach et al., 2013), (Robert Bosch GmbH, 2012), (Mathes et al., 2015)) and research ((Plum, 2016), (TUM LLCM, 2015)).

With this shift – from mobility to connected mobility – the classical mobility ecosystem, consisting mainly of automotive original-equipment manufacturers (OEMs), their specialized parts supplier contributing in the value chain of car manufacturing and public transportation and car rental companies offering complementary mobility to using the own car is rapidly accelerating. Digital giant such as Google and Apple are entering the mobility scene, especially in connecting with self-driving cars and autonomous driving ((Etherington and Kolodny, 2016), (Taylor, 2016)). As new groups of industries entering the ecosystem, established mobility players are forced to focus on innovation regarding the connectivity, safety and assisted driving (Mosquet et al., 2015). By offer-

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ing own mobility services, such as BMW's DriveNow (BMW Group, 2017) or Daimler's Car2Go (Daimler AG, 2017), the automotive OEMs are already addressing these changes. This holds true also for public transportation companies offering for example mobile scheduling and ticketing. Thus, the connected mobility ecosystem demonstrates innovative characteristics and a high dynamic.

The aforementioned elements are the main challenges of modeling the connected mobility ecosystem, which also includes a description of the industry structure.

The research approach could be considered as the first iteration of Hevner's three cycle view of the design science research framework (Hevner, 2007). The three cycles within this research framework correspond to:

- Relevance cycle: Identifying relevant entities and their relations, in the connected mobility industry by analysing related German companies. Although connected mobility is a topic of global relevance and interest, we consider that Germany offers a good starting point for the analysis of the connected mobility ecosystem, due to the strong history of automotive OEMs and suppliers.
- Design cycle: Representing the ecosystem model with a modified ego network visualization type focusing on mobility services. This approach is applied to the connected mobility ecosystem from a German perspective.
- Rigor cycle: Evaluating the existing literature of modeling business ecosystems, especially the data visualization following a data-centric approach and extend the existing models with an ecosystem services focus.

Additionally, we lay the groundwork for evaluating the requirements for a tool, which allows the ecosystem stakeholders to explore and thereby understand the connected mobility ecosystem from an user-centered design perspective.

The remainder of this paper is organized as follows: section 2 describes the process steps to visualize the connected mobility ecosystem with an user-centered approach. Subsequently, the German perspective of the connected mobility ecosystem is discussed in section 3 together with limitations of the approach in section 4. Finally, in section 5 we conclude and provide an outlook for future work.

2 VISUALIZING THE CONNECTED MOBILITY ECOSYSTEM

One possible way to support stakeholders in gaining a better understanding of the ecosystem their companies are acting in is applying a visual approach (Iyer and Basole, 2016). The resulting network visualizations are valuable for executives, venture capitalists and additional user groups in supporting them in their ecosystem related decisions and thus applying the "wide lens" (Basole et al., 2016).

To gain insights about the connected mobility ecosystem, we apply the proposed visual approach, which consists of the four process steps *(1) Determine industry structure, (2) Identify companies and their attributes, (3) Finalize semantics for nodes and dependencies* and *(4) Visualize, analyze, and interpret.*

2.1 Determine Industry Structure

The first step of the visual approach to understand ecosystems is analyzing the industry structure (i.e., the connected mobility industry). To identify and determine the value chain of the connected mobility, industry and trade publications and newspaper articles addressing the connected mobility were considered (e.g., (Rossbach et al., 2013), (Robert Bosch GmbH, 2012), (Mathes et al., 2015), (Mosquet et al., 2015)). The identified stack is shown in Table 1.
Additional to the classic mobility ecosystem players – the automotive OEMS, their parts suppliers, car rental agencies and public institutions offering public transportation – new industry groups gain relevance.

The first addition to the classic mobility stack are technology companies, which vary from companies focusing on advanced driver assistance systems, machine learning, artificial intelligence to cyber security (Nayak, 2016), all addressing the digitized advancements of mobility. These companies enrich the mobility environment by adding completely new services, such as the Starship's delivery robot, or by supplying automotive OEMs with software and hardware, such as thinkstep's data analysis software. For a better understanding of the influence of technology companies on the ecosystem, a further subdivision of this group is envisioned for the future.

Companies offering the transmission of data and providing access to mobility services are bundled in the platform and connectivity provider group. Thereby, they play an important role in enabling digitized mobility, connecting users to the provided services.

Table 1: Identified connected mobility stack.

Automotive OEMs	For example, BMW, Volkswagen, Mercedes
Parts Supplier	For example, Robert Bosch, Drxlmaier, Continental, Denso
Technology Companies	For example, thinkstep AG, Panoratio, Starship Technologies, Siemens
Platform & Connectivity Provider	For example, Deutsche Telekom, Vodaphone, Google, RideCell
New competitors of affected industries	For example, Allianz, RWE, Sixt
Public Institutions	For example, City of Munich, SWM (Munich City Utilities operating inner city city public transportation), StMWi (Bavarian Ministry of Economic Affairs and Media, Energy and Technology)

Mobility services address the user's wish for mobility as a service, which is "a mobility distribution model in which all users major transport needs are met over one interface and are offered by mobility operators" (ITS Finland, 2015). Mobility services gaining more and more importance, especially in cities, and might even be the future of OEMs business, replacing the automotive production and sales (Botsman, 2015). Using mobility services to get from point A to B, mobility consumers have the option to choose several means of transportation. Especially popular and widely discussed became transportation network companies (TNCs) as mobility services, such as Uber, Lyft or Gett, which connect private drivers using their own cars to passengers searching for a lift.

New competitors of affected industry also recognize the advancements in connection with digitized mobility. An obvious example are insurance companies, offering insurance rates depending on driving habits or user's general mobility footprint. Other industries are energy providers, addressing the charging challenge in connection with e-mobility. As the affected industries – compared to other groups of the connected mobility ecosystem stack – participate but not shape the ecosystem, they are collectively represented.

The last group of entities, identified in the connected mobility ecosystem, covers public institutions including public transportation companies in the classic mobility ecosystem. These companies have to adapt to the digitized service landscape for example by proving online travel planning and ticketing. However, of even greater importance are public institutions responsible for legal and tax regulations. They have the power and ability to influence the mobility ecosystem by enabling business models or forestalling them. Especially in the context of privacy of mobility data and the liability in context with autonomous driving, new regulations are necessary (Collingwood, 2016), which will form the connected mobility ecosystem.

The separation of these identified groups of ecosystem entities is not strict, as entities might fit into more than one group. This will be considered in the refinements of the stack, which are necessary since the ecosystem further evolves.

2.2 Identify Companies and Attributes

To understand the connected mobility ecosystem, for all identified industry groups of the connected mobility stack (see Table 1) companies and their attributes have to be gathered and documented. Additionally, the type of relationship between these entities is required to understand the interaction within the ecosystem. Thereby, the type of relationship varies from negotiation and failed talks, investments, partnership or cooperations, personnel move to acquisitions. With the large amount of entities in the connected mobility ecosystem and their various types of relations, an understanding of the ecosystem is a challenging task.

Following the aforementioned visual approach (Iyer and Basole, 2016) industry publications, internet search engines, news portals, and websites, but also company's websites should be evaluated to gather relevant entities of the ecosystem and their relations.

2.3 Visual Model Language

From the data model perspective, the connected mobility ecosystem can be modeled using a graph. The entities (i.e., the companies and their attributes) are the nodes and their relations are the links. The graph model allows the visual representation of the ecosystem using the traditional information visualization

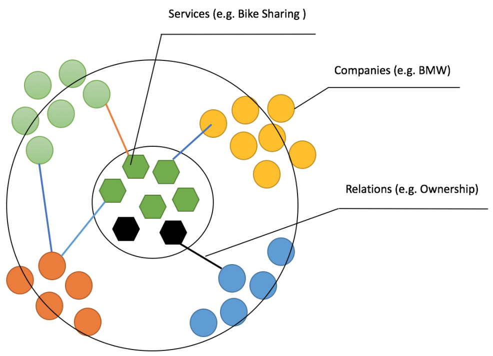

Figure 1: Proposed ego network visualization for the connected mobility ecosystem.

techniques such as Adjacency Matrix[1] and Node-Link diagrams[2]. However, the visualization of graph models are a challenging task in the area of information visualization (Iyer and Basole, 2016).

In this paper, we proposed a modified ego network visualization[3] where the focus is on the mobility services provided in the ecosystem (see Figure 1). The center of the visualization contains the mobility services represented using hexagons as marks. Additionally, the entities are represented as circles, grouped into categories of the connected mobility ecosystem stack (see Table 1). Finally, each category and type of relation between entities is mapped to a different color, using a 30 colors scale to differentiate them in the graph.

2.4 Interpretation

By putting the mobility services in the center of the visualization, we adopt an user-centered view, as these services have direct interfaces to the mobility users, addressing the need for mobility as a service. This visualization enables the ecosystem stakeholder to gain an understanding of which and how companies are collaborating to provide a mobility service. Additionally, relations – and with that entities – are identified, which do not link and thus contribute to any mobility service, suggesting that these companies might have a backlog adjusting to digitized mobility. By visualizing all relations necessary to provide a mobility service, the complexity of the provided mobility service are demonstrated.

The presented visualization might thereby help stakeholders of the connected mobility in addressing the trend from products towards (mobility) services (Bosch, 2016).

[1]https://en.wikipedia.org/wiki/Adjacency_matrix
[2]https://en.wikipedia.org/wiki/Graph_drawing
[3]http://www.analytictech.com/networks/egonet.htm

3 VISUALIZING THE CONNECTED MOBILITY ECOSYSTEM FROM A GERMAN PERSPECTIVE

In a next step, the previously described approach is applied to the connected mobility ecosystem. The German automotive industry, being the largest industry in Germany, comprising not only of world leading automotive OEMs and tier-1 suppliers, but also – with around 85 % – of medium-sized Tier 2 and 3 supplier (Germany Trade & Invest, 2013). As these companies are also affected by the changes of mobility, analyzing the connected ecosystem from a German perspective serves as a valid starting point for the collection and evaluation of relevant data.

3.1 Identify Companies and their Attributes

By applying a German perspective on the connected mobility ecosystem, we collected data starting with established German OEMs and their supplier network. By analyzing the OEMs web presence and published reports, the relations between OEMs and supplier were identified. Additional to these classic mobility ecosystem entities and relations, the mobility services already provided by OEMs were documented, including the associated relation. The same was applied to companies providing public transportation.

In a next step – to gather new ecosystem entities and their relations – publicly accessible data sources were collected and evaluated. The number of these databases is huge, ranging from national databases, e.g. Gründerszene[4] or Bayern- International[5], to international ones, e.g. Crunchbase[6] or AngelList[7].

To identify especially technology companies for this work, the database Crunchbase was used, which provided a limited but free of charge access. Companies are tagged with attributes describing their field of action, for example, ”Transportation” or ”Mobile”. By searching for German automotive OEMs, relevant funding and acquisitions were identified using Crunchbase. Additionally, news feeds were scanned and evaluated regarding cooperations of German automotive OEMs, mobility services, technology companies and affected industries.

[4]http://www.gruenderszene.de/
[5]http://www.bayern-international.de/en/
[6]https://www.crunchbase.com
[7]https://angel.co/

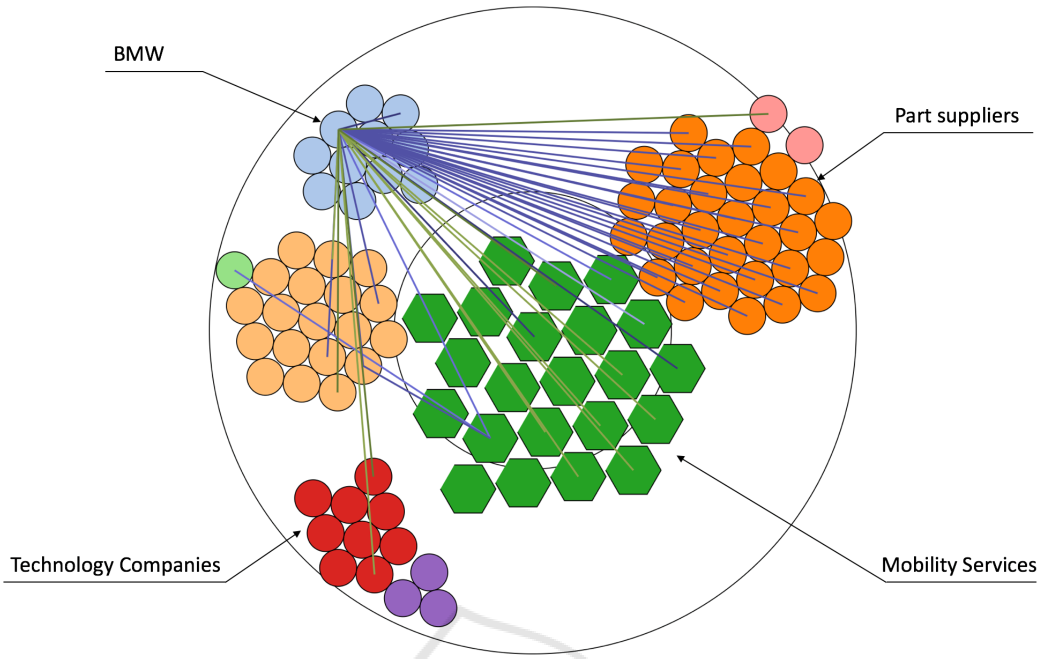

Figure 2: The connected mobility ecosystem from a German perspective.

Conducting the above-described steps, an overall sum of 97 connected mobility ecosystem companies and 192 associated relations were collected and documented.

3.2 Visualize the Connected Mobility Ecosystem Explorer from a German Perspective

The collected data relevant to the mobility ecosystem from a German perspective is visualized in Figure 2. Due to the high amount of entities and relations, we filtered the data and visualized one company and its relations. Thereby, we chose the BMW group due to its size and relevance for the German industrial landscape.

3.3 Interpretation

The visualization validates that the BMW group is highly involved in providing mobility services, and thereby adapting to the changes in context with digitized mobility. It shows the strong integration with German automotive part suppliers and already established technology companies enriching the mobility ecosystem.

By filtering for other companies, the same understanding of involvement in the connected mobility ecosystem can be gained.

4 DISCUSSION

By using the presented visual approach and applying it to connected mobility ecosystem, we realized the following limitations.

First, the data gathering in this context is immensely time-consuming. Although established automotive OEMs share their activities regarding provided mobility services openly, they are rather conservative with sharing collaboration information. To gather this kind of information all potential enterprises, supplying automotive OEMs with technology or hardware, have to be analyzed, in addition to industry publications, news portals and websites. That is why we envision to explore techniques like crowdsourcing – also in combination with gamification approaches – to gather data enriching the process and thereby the ecosystem.

Furthermore, the data model and the identified categories are constantly evolving, as the ecosystem is, and thus key attributes change. The presented visualization and with this the underlying tool providing the visualization have to adapt to these constant changes.

Finally, the visual languages presented in this work must be enlarged to address the clear separation between mobility services and mobility service provider including suppliers of mobility services. Additionally, the different kind of relations between ecosystem entities are not yet encoded in the visual language. Due to the high amount of relations, especially for automotive OEMs and part suppliers, the proposed visualization language is only feasible when selecting one specific ecosystem entity.

5 CONCLUSION AND FUTURE WORK

In this paper, we presented a model of the connected mobility ecosystem, which contains a description of the connected mobility industry. The provided visualization fosters the understanding of the interaction of ecosystem companies providing different mobility services. Thereby, ecosystem stakeholders, which are not directly involved in providing a service, can gain knowledge about mobility services they are enabling by providing their services. Secondly, the knowledge about what components are necessary to provide a mobility service is increased.

We plan to continue researching on the presented visual approach of the connected mobility ecosystem, in order to address the limitations discussed previously. We envision a connected mobility ecosystem explorer focusing on the user-centered visualization and interpretation of the connected mobility environment. In order to provide such a tool, the various mobility scenarios will be gathered, evaluated and visualized.

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