Using Tangible Modeling to Create an e^3*value* Conceptual Model for Digital Ecosystems

Nedo Bartels[1] ✉ [0000-0002-2540-6264], Roel Wieringa[2] [0000-0003-2121-9928], Matthias Koch[1] [0000-0002-7640-5237], Karina Villela[1] [0000-0002-4643-7588], Daniel Suzumura[1] [0000-0002-9200-0272], and Jaap Gordijn[3,2] [0000-0002-6401-3850]

[1] Fraunhofer IESE, Kaiserslautern, Germany,
{nedo.bartels,matthias.koch,karina.villela,daniel.suzumura}@iese.fraunhofer.de
[2] The Value Engineers, Soest, The Netherlands,
{roel,jaap}@thevalueengineers.nl
[3] Vrije Universiteit, Amsterdam, The Netherlands, j.gordijn@vu.nl

Abstract. The design of digital platforms and ecosystems is a challenging problem that involves technical, organizational, and business aspects. In this context, modeling languages for creating conceptualizations are crucial to support the design of comprehensive ecosystems. However, the creation of conceptual models requires the input and expertise of practitioners, who usually do not have the time to learn modeling languages. In this paper, we explore how to overcome this challenge by combining a tangible design approach for ecosystems, named the Tangible Ecosystem Design (TED) methodology, with a value modeling approach named the e^3*value* methodology. We created and analyzed a TED Service Map and a corresponding e^3*value* model to formulate lessons learned based on a comparison of models. Our results suggest that (1) the design process of a value model can benefit from tangible modeling and (2) model elements can be partially transferred from TED models to e^3*value* models. The contribution of this paper provides lessons learned that can be used to derive e^3*value* models from the TED approach and thereby lower entry barriers for conceptual models of complex ecosystems.

Keywords: e^3*value* · tangible ecosystem design · tangible modeling · value modeling · business models · digital ecosystems

1 Introduction

Regardless of the domain, the emergence of digital platforms and ecosystems is changing markets and sectors [21]. As a consequence, companies try to (re-)define their own business strategies regarding how to create and capture values [27]. We define a *digital ecosystem* as a 'collection of companies that work cooperatively and competitively to satisfy customer needs' [16] by providing digital products or services. Here, we consider a *digital platform* as a specific kind of an *ecosystem*, with the addition that the platform offers platform services used frequently by all actors of an ecosystem. A digital platform is offered by one or more *asset broker(s)*, which enable the exchange of *assets* between their *asset providers* and *asset consumers*. Often, but not necessarily, a platform is provided by a single party such as Airbnb, Uber, eBay, etc. [14].

For digital ecosystems, a *business model* can be designed that conceptualizes how economic value is created, distributed, and consumed in a network of parties. The e^3*value* methodology [5] allows the notion of models as an abstraction of reality according to a certain conceptualization [8]. A challenge to be faced is how to transfer the use of the e^3*value* methodology to practitioners, e.g., how to facilitate wide-spread adoption of the methodology in the field. One of the problems experienced, according to the developers of e^3*value*, is that practitioners find it hard to develop precise and accurate conceptual models in general. The same holds for e^3*value*, despite the effort of its developers to keep the complexity of the e^3*value* methodology to the bare minimum [4].

One easy-to-use method for designing business models is the Business Model Canvas (BMC) [20]. However, BMC is (1) intended for business cases with one focal actor and its direct key partners and key customers, whereas we are interested in full ecosystems (because digital innovation affects all parties in an ecosystem, not just one), and (2) is restricted in its expressive power (nine building blocks without formal syntax or semantics do not cover a full ecosystem). As a consequence, BMC is not very suitable for carrying out various kinds of analyses such as ecosystem-wide net cash flow analysis, risk and fraud analysis, etc. We argue that applying these analyses techniques should be an intrinsic part of any ecosystem (re-)design process, and should also be integrated with the conceptualization technique(s) used. Current methods and frameworks lack guidance for tacking the complex and long-term task of ecosystem design [28].

Because people find it hard to conceptualize ecosystems in general [23] and to use e^3*value* in particular, the question arises of whether we can offer people assistance to do so. A solution that we explore in this paper is the combination of e^3*value* methodology, and *tangible modeling*, specifically the *Tangible Ecosystem Design* (TED) methodology [17], which uses Playmobil® toys like figures, cars, and objects together with a set of print templates to design digital ecosystems systematically. Experience has shown that the TED methodology makes ecosystem concepts more concrete and understandable, as well as making the process of designing ecosystems easier for participants [17][18].

Similar to [11], we propose tangible modeling and the use of physical components as a design approach to support the subsequent ecosystem modeling process. This paper explores the relationship between TED and e^3*value* to the extent that a TED *Service Map* (SM) model (see Sec. 4) can be used to derive and initiate an e^3*value* model (see Sec. 5) to make the process of the e^3*value* methodology more accessible to practitioners. Therefore, our *research question* is: What are the semantic similarities between a TED Service Map model and an e^3*value* model?

This paper is structured as follows. In Sec. 2, we introduce relevant related work. Sec. 3 presents the study design. Then Secs. 4 and 5 introduce the two methodologies used in the paper, namely TED and e^3*value*. Sec. 6 presents the core of the paper, i.e., how a TED Service Map model can be related to an e^3*value* model, showing a set of lessons learned. Finally, Sec. 7 presents our conclusion and future work.

2 Related Work

In the past, the conceptual modeling and requirements engineering community have proposed a large portfolio of modeling techniques. They developed languages such as e^3*value* [5], *i** [24], BPMN [19], SSN [1], SEAM [3], and the UML [7] family to mention but a few, and studied how to use these techniques in *combination* for the purpose of understanding ecosystems (see e.g. [25, 15, 10, 23]). These techniques are perceived as useful for creating *conceptual models* for modeling ecosystems, but practitioners often find them hard to use [13]. There are multiple reasons for this (see the observations of [23]), but similar to [12], we claim that conceptualization (of what all these techniques do) is hard by *nature*, requires effort and handling, and practitioners do not have the time to learn a modeling language. Evidence provided by [12] shows that tangible modeling languages, i.e., languages whose concepts are represented by physical objects, such as plastic toy figures, have positive effects on collaborative modeling efforts and can lead to better conceptual models [6][17][22]. The experiments of [12] indicate a beneficial impact of *iconicity* (similarity between sign and object) on participants' understanding, modeling speed, and model quality, which can be enhanced by the *tangibility* of physical objects. Moreover, according to [6], practitioners achieve a better understanding, there is greater consensus, and rate of adoption of the results is higher.

Based on existing literature indicating the potential of tangible modeling for the ecosystem design process [13][11][2][6], we identified a lack of research on approaches and experiences that demonstrate the combination of tangible modeling with value modeling techniques for the design process of digital ecosystems. Therefore, we are exploring for the first time the combination of tangible modeling of TED, which uses physical artifacts to represent actors and exchanges within a digital ecosystem, and the value modeling approach of e^3*value*.

3 Relating TED and e^3*value* : Study design

The goal of this paper is to understand how tangible modeling in general, and TED in particular, relates to value modeling, e.g., e^3*value*. Although we chose to combine TED and e^3*value* because we are familiar with both methodologies, we do not rule out other approaches. Understanding this relationship is important for using tangible modeling as a tool to lower the barriers for practitioners to create meaningful and correct e^3*value* models. Given the nature of TED SM models, we expect semantic overlap of a TED SM model with an e^3*value* model, and hence the TED SM model is useful input for an e^3*value* model. To establish this, our research followed three steps. (1) To find out whether TED and e^3*value* can be meaningfully related, a real-life project carried out by Fraunhofer IESE was used. The aim of the project was to develop a digital ecosystem for a mobility platform. In order to understand all technical, organizational, and business aspects of the digital ecosystem, a series of TED workshops with stakeholders was carried out, resulting in a number of tangible models, including the TED SM model (see Sec. 4). Since the design process of the TED SM model is not part of this work, the workshops are not presented in detail. (2) Taking the TED SM model for the digital ecosystem of the mobility platform, researchers from Fraunhofer IESE and *The Value Engineers* (TVE) jointly developed the corresponding e^3*value* model. This development was led by e^3*value* experts. The result is a valid e^3*value* model (Sec. 5) to the corresponding e^3*value* methodology. (3) The two models the TED SM model and the e^3*value* model were compared in order to derive similarities. Our observations on the similarities between the TED SM model and the e^3*value* model are formulated as lessons learned (see Section 6.5) and need to be evaluated in the future.

Since ecosystem modeling can be considered as a design problem, and thus a case of Design Science [9], we intend to use our formulated findings to provide design guidelines for deriving an e^3*value* model from a TED SM model in the future.

4 The TED methodology for ecosystem design

The goal of the *Tangible Ecosystem Design* (TED) methodology is to support the design of *digital ecosystems*, which are socio-technical systems connecting multiple, typically independent providers and consumers of assets. The TED methodology is an interactive workshop approach to help ecosystem initiators identify and understand interactions and exchanges among their actors. By combining touchable Playmobil® toy figures with proven creativity techniques, TED can be used to design a tangible, concrete, and touchable model of a digital ecosystem (see, e.g., Fig. 1). The TED methodology consists of three components, which are ideally conducted in interactive workshops. These workshops can be held together in presence or virtually - associated materials exist for both scenarios [26]. The three components of the TED methodology are:

1. *Service Blueprint*. The goal of the Service Blueprint is to map the activities and interactions of the platform users and systems and to define a user journey (e.g., user opens app, user registers, user sets payment method, etc.). In doing so, the workshop participants also define various processes and activities along their user journey via different layers: (1) user activities, (2) interactive system activities, (3) system activities in the background, and (4) organizational or contractual prerequisites. An example of a service blueprint can be found in [26].
2. *Service Map* (SM). The goal of the SM model is to determine the roles of the actors in the digital ecosystem, to work out the exchanges between them, and to define a possible revenue model. The elements of the SM primarily include actors and different kinds of flows such as money-, asset-, and data flows,

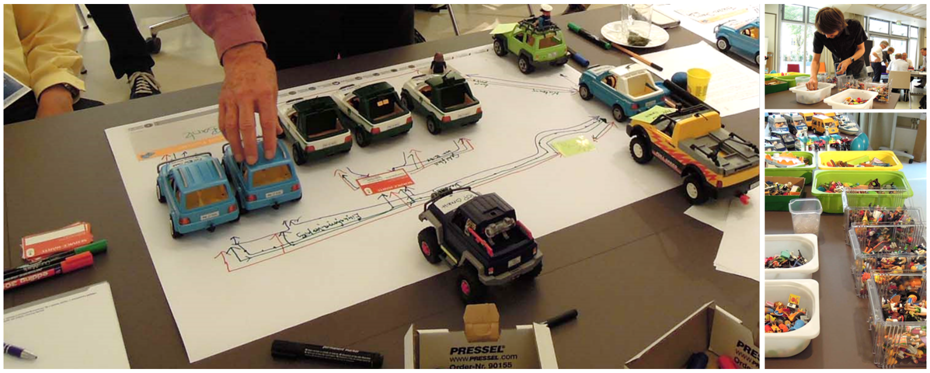


Fig. 1: Impressions of a TED workshop.

and contractual relationships. It has been shown in the TED workshops that a process-like mindset helps participants to model complex exchanges in the SM. However, the SM is not a process model. A representation of a TED SM model can be seen in Fig. 2.

3. *Motivation Matrix*. The aim of the Motivation Matrix is to identify the benefits and values for each actor participating in the digital ecosystem. For each actor, a comparison is made between what is expected through participation and what the digital ecosystem actually enables. A representation of a Motivation Matrix can be seen in [26].

In terms of scope, this paper focuses mainly on the TED SM model, as it defines the ecosystem actors and its interactions similar to a value model in e^3value. Fig. 2 presents a TED SM model for Airbnb.

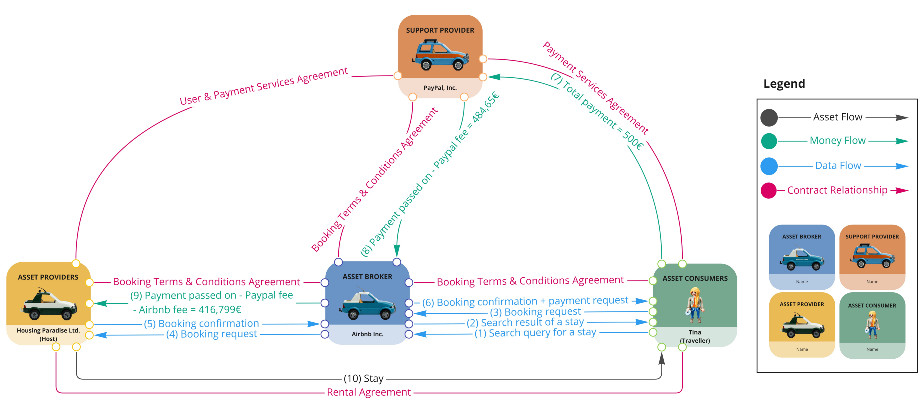


Fig. 2: Example representation of a TED SM using the example of Airbnb

5 The e^3*value* methodology for ecosystem value modeling

The e^3*value* methodology creates a value model that represents a network of actors that create, transfer, and consume things of economic value. We assume that the reader is familiar with e^3*value*, otherwise, we refer to [5]. To illustrate e^3*value* and TED with common knowledge, Fig. 2 and Fig. 3 present a simplified version of Airbnb. Similar to the TED model in Fig. 2, the value model in Fig. 3 shows the interactions between the Airbnb platform and its hosts, visitors, and the payment service PayPal.

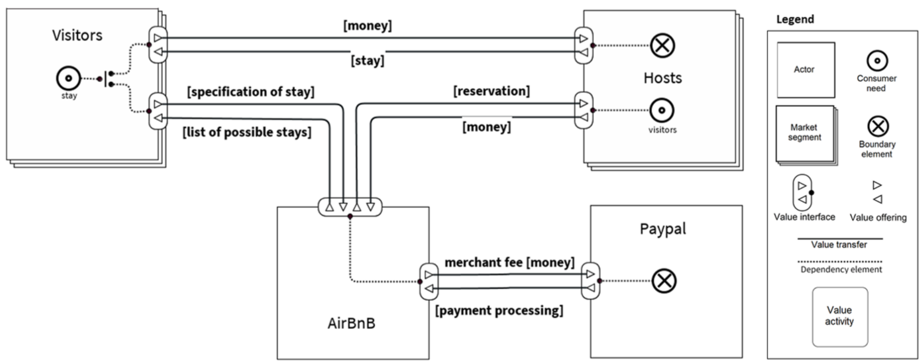


Fig. 3: Example representation of an e^3*value* model using the example of Airbnb

6 Relating the TED SM to e^3*value* : The Mobility Platform

We will first present the use case we considered and then show the corresponding TED SM model and e^3*value* model. We will discuss the correspondences between the two models and then formulate them as lessons learned.

6.1 Use Case – digital platform for mobility services

The goal of the considered mobility platform is to build an open-source, standardized platform to enable innovative mobility services. Therefore, local trip planners (referred to as *multimodal mobility operator*) can use the mobility platform as a marketplace to combine mobility services (e.g. taxi cabs), data sources (e.g., traffic situation), and mobility process services (e.g., parking systems) to promote innovative mobility services to passengers. The vision of the mobility platform is to (1) create a marketplace for innovative mobility services, (2) ensure interoperability between different modes of mobility, and (3) make it easier for passengers to use bundled mobility services and trips. From a technical perspective, the mobility platform should be based on open-source components and semantic web technologies. The mobility platform includes the following actors:

- *Mobility platform:* provides the digital platform and the marketplace, which connects mobility services with, mobility-related data sources and process services.
- *Multimodal mobility operator:* offers a trip planning service for the intelligent bundling of mobility services to enable passengers to get a complete mobility solution.
- *Mobility provider:* provides a single (or multiple) mobility service(s), such as taxi cabs, buses, trains, and e-scooters, to transport passengers.
- *Data provider:* offers mobility-related data sources, such as traffic and weather situation or local events that affect mobility conditions.
- *Processing service provider:* offers mobility-related process services, such as parking systems.
- *Passenger:* consumes the mobility services, and can be seen as an end-customer.

In order to realize the platform vision and generate value for each actor, the project was faced with designing a suitable business model to ensure economic success in the long term. The TED SM model in Fig. 4 was derived based on the results on several workshops with project partners, domain experts, and legal experts working in the mobility sector. These workshops were conducted physically and was led by two researchers from Fraunhofer IESE. From the resulting model an e^3*value* model was derived. Here, it should be pointed out that the design process of the two models is not part of this work; rather, the focus is on the derivation of an e^3*value* model, shown in Fig. 5, from a TED SM model, shown in Fig. 4.

6.2 TED SM model for the mobility ecosystem

We will briefly summarize the TED SM model based on the numbered flow sequences 1-4 in Fig. 4. *1st flow sequence: passenger's request for mobility services.* The passenger makes a mobility request to the multimodal mobility operator, who then forwards this request to the mobility platform. The mobility platform then requests the best travel mode from the processing service providers, the current traffic situation from the data provider, and corresponding mobility offers from the mobility providers. *2nd flow sequence: actors' response via mobility platform.* Relevant traffic data and process travel modes as well as the available mobility offers are then sent via the mobility platform to the multimodal mobility operator, who bundles them into a complete mobility offer and forwards this to the passenger. *3rd flow sequence: booking process.* The passenger confirms the compiled mobility offer by initiating a booking with the multimodal mobility provider. The multimodal mobility provider sends the booking data to the mobility providers, who in turn issue their access authorization to the mobility

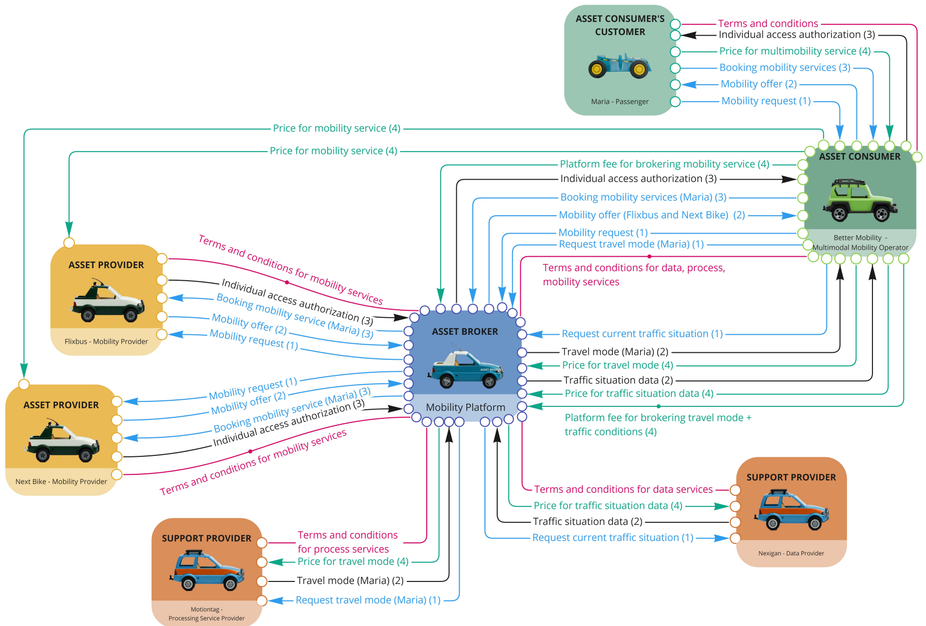


Fig. 4: TED SM model of the mobility ecosystem.

services. *4*th *flow sequence: payment process.* The payment process takes place in parallel with the booking process. The passenger pays the total price per booked trip to the multimodal mobility provider. The multimodal mobility provider retains a portion and passes the remaining amount on to the mobility service providers for their mobility services. The data and process service providers are paid by the multimodal mobility provider for providing traffic data and travel mode. In addition, the mobility platform receives a brokering fee from the multimodal mobility provider for the brokering of (1) mobility services, and (2) data and process services.

6.3 The e^3*value* model of the mobility ecosystem

Researchers from Fraunhofer IESE and TVE designed a possible e^3*value* model for the TED SM model. The design process was led by e^3*value* experts to ensure that the resulting model is correct. We need correct models to do proper similarity analysis between TED SM and e^3*value* models. The resulting value model is depicted in Fig. 5. For the sake of simplicity, those actors that fulfill similar roles were grouped together in the e^3*value* model; accordingly, a total of four market segments and one mobility platform as actor were modeled.

Starting with the passenger, there are two value transfers to the multimodal mobility operator, which clarifies the core exchange of a trip booking and money. Here, the multimodal mobility operator enables the value exchange by compos-

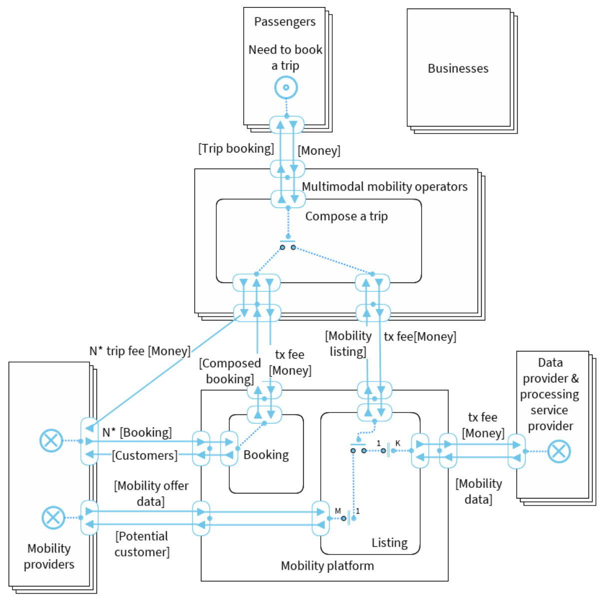


Fig. 5: e^3*value* model of the mobility ecosystem

ing a trip from bookable mobility services (e.g., taxi cabs, buses, e-scooter) and listed mobility information (e.g., best mobility offer during rush hour). The core of the e^3*value* model is the mobility platform with its value activities *listing* and *booking* and its ten value transfers. For the listing, mobility-related data from data providers is linked with the mobility offer data (e.g., seat availability) of mobility providers. For this, the data providers get paid by the multimodal mobility provider by means of a fee. The mobility providers use the platform primarily to acquire customers for their mobility services and to process bookings. Payment to mobility providers is not made through the mobility platform. In addition, the multimodal mobility operator pays the mobility platform a transaction-based brokerage fee for the use of the booking and listing functions.

6.4 Evaluation of the TED SM model and the e^3*value* model

Discussions were held with three experts who have knowledge of both ecosystem modeling and the project. In the discussions, both the TED SM model and the e^3*value* model were compared in order to validate overall model meaningfulness as well as semantic similarities and differences.

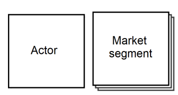
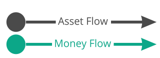
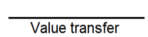
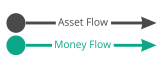
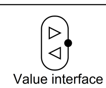
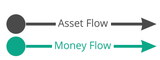
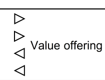
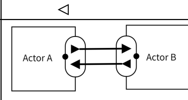
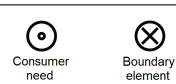
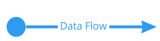
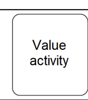
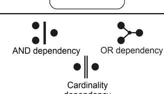
The experts discussed the completeness of the two models in terms of whether the support providers should be considered together as in Fig. 5 or separately (see data provider and processing service provider in Fig. 4). However, all three experts considered the e^3*value* model (Fig. 5) designed from the TED SM model (Fig. 4) as coherent and reasonable, and agreed that TED SM models and e^3*value* models have semantic overlaps. We assume that following a TED Service Map model can partly lead to an e^3*value* model.

6.5 Analysis of TED SM model and e^3*value* model correspondences

We formulated the similarities between the TED SM and an e^3*value* model as a set of lessons learned (see Table 1, and the subsequent discussion), which summarizes the experience we gained. These lessons learned were found by carefully analyzing both the TED SM and the corresponding e^3*value* model for semantic similarity.

To assess whether modeling elements of an e^3*value* model can result from a TED SM model, we formulated our lessons learned using three gradations: (1) *can lead*, in the case of a clear transfer from TED to e^3*value*; (2) *can partially lead*; in the case of a potential transfer, and (3) *not considered* in TED, in the case of no transfer. The structure of Table 1 is inspired by the guidelines of [25] regarding correspondence between BPMN and e^3*value* models.

Table 1: Lessons learned – from TED Service Map model to e^3*value* model

ID	TED elements	e^3*value* elements	Lessons learned
L1			Specified actors in TED SM *can lead* to actors and market segments in e^3*value*.
L2			TED SM asset flows, and money flows *can partially lead* to value transfers in e^3*value*.
L3			TED SM asset flows, and money flows *can partially lead* to value interfaces in e^3*value*.
L4			TED SM asset flows, and money flows *can lead* to value ports in e^3*value*.
L5			TED SM contract relationships *can partially lead* to value transactions in e^3*value*.
L6			TED SM actors *can partially* lead to consumer needs and boundary elements in e^3*value*.
L7			TED SM data flows *can partially* lead to value activities in e^3*value*.
L8	n/a		e^3*value* dependency elements are *not considered* in TED SM.

Observations extracted from the use case. In the following, we present the lessons we learned from the comparison between the TED SM model and the e^3*value* model in the context of the mobility ecosystem under consideration:

L1 *Specified actors in TED SM can lead to actors and market segments in* e^3value. The defined actors can be transferred directly into an e^3*value* model. One characteristic of the TED SM is the fine-grained classification of the different actors of a digital ecosystem. At the core of this classification is the fact that a concrete actor in a digital ecosystem can be an asset broker (e.g., Airbnb lodging platform) or a platform provider (e.g., Airbnb, Inc.), an asset provider (e.g., host), an asset consumer (e.g., traveler), a support provider (e.g., PayPal Holdings, Inc.), or a competitor (e.g., booking.com). Here, an actor can potentially switch roles (e.g. a host can also be a traveler and vice versa). Moreover, an actor can perform both roles at the same time, e.g., asset broker and platform operator are the same. Both TED and e^3*value* represent actors in an ecosystem, and by classifying them in TED, it is possible to accomplish almost a one-to-one translation of relevant market segments and actors in exchange in an e^3*value* model. A minor difference is that in the TED SM model, actors are made concrete with names in order to reflect a real-world case as tangibly as possible. In an e^3*value* model, a more abstract perspective is taken for defining actors. When creating the e^3*value* model, we found that the clear stakeholder classification in TED is conducive to the explicit determination of value transfers in e^3*value* (e.g., "Maria" as an asset consumer in Fig. 4 and "passenger" who want to consume mobility in Fig. 5. The same applies to "Flixbus" as an asset provider and "mobility providers" who want to sell mobility services).

L2 *TED SM asset flows, and money flows can partially lead to value transfers in* e^3value. Following asset flows and money flows in the TED SM model could partially help to model corresponding value transfers in the e^3*value* model. A *value transfer* is a concept within the e^3*value* methodology in which actors/entities exchange something of economic value. In an e^3*value* model, it is explicitly asked *what* exactly is exchanged and less *how* it is traded, as is the case with process models [5]. In a TED SM model, the transfer of economic value is represented by asset flows and money flows; however, the flows are represented in a more physical way, and show the direct exchange between actors, and less the actual value transfer. A value transfer can be derived from a TED SM model if an economic exchange can be indicated clearly between two actors. For example, the passenger pays a price (gives money) and gets an individual access authorization (gets mobility) to the mobility service from the multimodal mobility operator. However, when an economic exchange is split between actors and thus cannot be identified easily in a TED SM model, the transfer to an e^3*value* model is limited. Example: the mobility provider gives individual access authorization to the mobility platform but receives money from the multimodal mobility operator. Furthermore, we assume that data flows cannot be used to derive comprehensive value transfers, but can only complement other asset and money flows to indicate relevant information for value transfers in an e^3*value* model (e.g., mobility offer/request flow between mobility provider and mobility platform in Fig. 4).

L3 *TED SM asset flows, and money flows can partially lead to value interfaces in* e^{3}value*.* The paths of asset flows and money flows in a TED SM model can be used to indicate value interfaces in an e^3*value* model. A value interface groups all value ports and value offerings that are connected to a value transfer. A value interface is characterized by two aspects: *economic reciprocity* describes that an actor is willing to exchange a value object for another value object via its ports; and the exchange of value objects takes place *atomically* at the value interface level [5]. In a TED SM model, the concept of reciprocity is not described explicitly, but value transfers and thus value interfaces can be derived partially based on asset and money flows between two actors. TED data flows can further specify a considered value transfer.

L4 *TED SM asset flows, and money flows can lead to value ports in* e^{3}value*.* Following the directions of asset flows and money flows in a TED SM model can be partially used to model value ports in an e^3*value* model. A single *value port* of an actor is a willingness to provide or request value objects to or from other actors. All in-going and out-going value ports in combination create a *bundle* of value objects in a value interface [5]. The TED flow directions, indicated by the arrowhead, can be transmitted one-to-one as an in-going or out-going value port in e^3*value* (e.g., value ports in Fig. 5 between passengers and multimodal mobility provider, and the asset flow and money flow direction in Fig. 4).

L5 *TED SM contract relationships can partially lead to value transactions in* e^{3}value*.* A contractual relationship in a TED SM model can partially lead to a set of value transfers between actors. A *value transaction* is the set of value transfers between at least two actors, when a value interface is triggered (e.g. confirmation of a purchase on a website). In a TED SM model, contractual relationships includes, e.g., terms and conditions, and specify the contractual exchange of values between two parties (e.g. Maria as a passenger confirms the contractual condition to pay the price for the multimobility service and thus receives individual access to a mobility service).

L6 *TED SM actors can partially lead to consumer needs and boundary elements in* e^{3}value*.* The actor specification in TED can be used as a starting point to indicate customer needs and boundary elements in e^3*value.* A *customer need* is a lack of something valuable that the actor wants to acquire. A *boundary element* represents the limit of the scope of a value model [5]. Here, it can be assumed that asset consumers mostly have a customer need, while asset providers or support providers have boundary elements.

L7 *TED SM data flows can partially lead to value activities in* e^{3}value*.* We experienced that data flows are helpful to indicate value activities in e^3*value.* A *value activity* is a task performed by an actor that potentially results in a benefit for the actor. The data flows in TED SM implicitly show interactions between actors and allow making inferences about value activities in e^3*value* (e.g., see the platform service *booking* in Fig.5 and the data flow *booking mobility service* between mobility provider and mobility platform in Fig.4).

L8 e^{3}value *dependency elements are not considered in TED SM.* Dependency elements, i.e. AND/OR and cardinality operators, can not be derived from a TED SM model. AND/OR and cardinality dependencies are purely logical constructions, represent no time ordering, and clarify how input conditions must occur so that an output state appears (e.g., a train passenger's need is satisfied when the passenger gets ONE ride AND food OR drink). In a TED SM model, there are no dependency paths, especially since no logical connectors such as AND / OR operators are defined. A TED SM model does not consider an *internal perspective* for each actor. An internal perspective of value creation is more likely to be represented in a *TED Service Blueprint model*, which is not part of the scope of this paper.

Limitations. The results of this paper aim to facilitate ecosystem modeling, but the work is project-specific and can be generalized only to a limited extent. The lessons learned presented need to be tested with practitioners in the future to assess their usefulness. While initial discussions with experts confirm that the designed conceptual models are reasonable and that the combination of tangible and value modeling has potential, we would like to strengthen our results by further validations.

In the future, multiple use cases are required to uncover missing relations that might not have been addressed in this work. The Airbnb example in Fig. 2 and Fig. 3 serves only for methodological explanation, however, it helps to illustrate *L2*; the difference between a physical flow in TED and an economic exchange in e^3*value*. In the TED SM model, three parties are physically connected as the traveler transfers money to the Airbnb lodging platform via PayPal. Compared to the e^3*value* model, only a single value transfer between the Airbnb lodging platform and PayPal is modeled to focus on the economic exchange: PayPal provides its payment service and receives money. Further investigation is needed in order to ascertain the accuracy of tangible modeling for e^3*value* models.

7 Conclusion and Future Work

We analyzed the semantic overlaps between the elements of TED SM models and e^3*value* models in a real-life project in the mobility sector. This work is ongoing research and our findings are based on a single case. However, our preliminary insights indicate that the design process of a value model can be improved from previously designed TED SM model. How to use this overlap to construct better e^3*value* models is part of future work.

As part of follow-up research, we are planning a series of workshops to identify guidelines and a step-by-step way for deriving an e^3*value* model from the results of a TED workshop. Also, in upcoming research, we need to find out whether tangible modeling in general, and TED in particular, helps to lower the barriers for practitioners to engage in an e^3*value* modeling process.

Acknowledgments. We thank Daniel Krohmer for scientific feedback and Sonnhild Namingha for linguistic revision.

References

1. Boucharas, V., Jansen, S., Brinkkemper, S.: Formalizing software ecosystem modeling. In: Proceedings of the 1st International Workshop on Open Component Ecosystems. p. 41–50. IWOCE '09, Association for Computing Machinery, New York, NY, USA (2009). https://doi.org/10.1145/1595800.1595807
2. Brophy, C., Stewart, C., Amayo Caldwell, G., Donovan, J., Teixeira, M.F.L.A., Dedehayir, O., Brogden, L.: Designing an open innovation orchestrator: the case of australia's advanced robotics for manufacturing (arm) hub. CERN IdeaSquare Journal of Experimental Innovation **4**(1), 16–22 (Jul 2020). https://doi.org/10.23726/cij.2020.949
3. Dahalin, Z., Razak, R.A., Ibrahim, H., Yusop, N., Kasiran, M.: An enterprise architecture methodology for business-IT alignment: Adopter and developer perspectives. Communications of the IBIMA pp. 1–17 (Jan 2011). https://doi.org/10.5171/2011.222028
4. Gordijn, J., Akkermans, H.: Early requirements determination for networked value constellations: A business ontology approach. Tech. rep., Vrije Universiteit (2006), `https://dise-lab.nl/wp-content/uploads/2021/06/EarlyReqDet2006.pdf`
5. Gordijn, J., Wieringa, R.: E3value User Guide - Designing Your Ecosystem in a Digital World. The Value Engineers, 1st edn. (2021)
6. Grosskopf, A., Edelman, J., Weske, M.: Tangible business process modeling – methodology and experiment design. In: Business Process Management Workshops, pp. 489–500. Springer Berlin Heidelberg (2010). https://doi.org/10.1007/978-3-642-12186-9˙46
7. Group, O.M.: Unified modeling language. `https://www.uml.org/` (2022)
8. Guizzardi, G.: Ontological foundations for conceptual modeling with applications. In: Notes on Numerical Fluid Mechanics and Multidisciplinary Design, pp. 695–696. Springer International Publishing (2012). https://doi.org/10.1007/978-3-642-31095-9˙45
9. Hevner, A., March, S., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly: Management Information Systems **28**(1), 75–105 (2004)
10. Huemer, C., Schmidt, A., Werthner, H., Zapletal, M.: A uml profile for the e 3-value e-business model ontology (2008)
11. Ionita, D.: Model-Driven Information Security Risk Assessment of Socio-Technical Systems. Ph.D. thesis, University of Twente, Netherlands (Mar 2018). https://doi.org/10.3990/1.9789036544832, iDS Ph.D. Thesis series No. 18-456 SIKS Dissertation Series No. 2018-06
12. Ionita, D., Nazareth, D., Vasenev, A., van der Velde, F., Wieringa, R.: The role of tangibility and iconicity in collaborative modelling tasks, pp. 1–14. CEUR (Nov 2017), eR Forum/Demos 2017, ER ; Conference date: 06-11-2017
13. Ionita, D., Wieringa, R., Bullee, J.W., Vasenev, A.: Tangible modelling to elicit domain knowledge: An experiment and focus group. In: Conceptual Modeling, pp. 558–565. Springer International Publishing (2015). https://doi.org/10.1007/978-3-319-25264-3˙42
14. Koch, M., Krohmer, D., Naab, M., Rost, D., Trapp, M.: A matter of definition: Criteria for digital ecosystems. Digital Business **2**(2), 100027 (2022). https://doi.org/10.1016/j.digbus.2022.100027

15. Kostova, B., Gordijn, J., Regev, G., Wegmann, A.: Comparison of two value-modeling methods: e^3*value* and SEAM. In: 2019 13th International Conference on Research Challenges in Information Science (RCIS). IEEE (May 2019). https://doi.org/10.1109/rcis.2019.8876991
16. Moore, J.F.: The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems. Wiley Harper Business (1996)
17. Nass, C., Trapp, M., Villela, K.: Tangible design for software ecosystem with playmobil. In: Proceedings of the 10th Nordic Conference on Human-Computer Interaction. p. 856–861. Association for Computing Machinery, New York, NY, USA (2018). https://doi.org/10.1145/3240167.3240278
18. Nass Bauer, C., Trapp, M.: Tangible ecosystem design: Developing disruptive services for digital ecosystems. In: Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems. p. 1–5. Association for Computing Machinery, New York, NY, USA (2019). https://doi.org/10.1145/3290607.3298819
19. OMG, Parida, R., Mahapatra, S.: Business process model and notation (bpmn) version 2.0. Object Management Group **1**(4), 18 (2011)
20. Osterwalder, A., Pigneur, Y.: Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. The Strategyzer Series, Wiley (2010)
21. Parker, G.G., Van Alstyne, M.W., Choudary, S.P.: Platform revolution: How networked markets are transforming the economy and how to make them work for you. WW Norton & Company (2016)
22. Rettig, M.: Prototyping for tiny fingers. Communications of the ACM **37**(4), 21–27 (Apr 1994). https://doi.org/10.1145/175276.175288
23. Sadi, M.H., Yu, E.: Designing software ecosystems: How can modeling techniques help? In: Enterprise, Business-Process and Information Systems Modeling, pp. 360–375. Springer International Publishing (2015). https://doi.org/10.1007/978-3-319-19237-6˙23
24. Sadi, M.H., Yu, E.: Analyzing the evolution of software development: From creative chaos to software ecosystems. In: 2014 IEEE Eighth International Conference on Research Challenges in Information Science (RCIS). IEEE (May 2014). https://doi.org/10.1109/rcis.2014.6861055
25. da Silva Torres, I., Fantinato, M., Branco, G.M., Gordijn, J.: Design guidelines to derive an e3value business model from a bpmn process model in the financial securities sector. In: The Practice of Enterprise Modeling. pp. 153–167. Springer International Publishing, Cham (2021). https://doi.org/10.1007/978-3-030-91279-6˙11
26. Tamanini, J.V., Koch, M., Nass, C.: Digitale Ökosysteme virtuell greifbar machen geht nicht? – doch! `https://www.iese.fraunhofer.de/blog/digitale-oekosysteme-greifbar-machen/` (2020)
27. Täuscher, K., Laudien, S.M.: Understanding platform business models: A mixed methods study of marketplaces. European Management Journal **36**(3), 319–329 (Jun 2018). https://doi.org/10.1016/j.emj.2017.06.005
28. Tsai, C.H., , Zdravkovic, J., Stirna, J., and: Modeling digital business ecosystems: A systematic literature review. Complex Systems Informatics and Modeling Quarterly (30), 1–30 (Apr 2022). https://doi.org/10.7250/csimq.2022-30.01