# Comparison of Two Value-Modeling Methods: $e^3$*value* and SEAM


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***Abstract*—In the last few decades, several value-modeling methods have emerged in requirements engineering for IS research. We compare two value-modeling methods, $e^3$*value* and SEAM. We illustrate their use with an example of the exchange of the Intellectual Property Rights (IPR) on music. In the process, we propose a comparison framework. The results of our study show that $e^3$*value* and SEAM are similar value-modeling techniques: both model services in networked systems and focus on value exchanges. They differ, however, in the way value is conceptualized: the market viability of the service system in $e^3$*value* versus the subjective value and lack of market profitability analysis in SEAM. $e^3$*value* shows how value flows from one actor to another, whereas SEAM shows the relative importance of different value propositions and how they are constructed by the service network. These results can be used by modelers to select a value-modeling method for their purposes by proposing explicit selection criteria. The comparison framework, which is in its early stages of development, can be used to compare other modeling methods.**



***Index Terms*—Value modeling, Services, Conceptual modeling, Comparison framework**


## I. Introduction

Value is a widely used concept in the IS field. It is a core concept in industry's good practices for IT, such as ITIL [1], and it is a cornerstone in research areas, such as service science [2], [3] and business theory [4]. The IS research domain is closely related to value-based theories from requirements engineering [5] and software engineering [6]. For many years, the computer-science field has been trying to represent how technology advancements provide value to users. There are different ways to interpret and represent value; the most often used one is to measure economic value. Service science provides another interpretation: value [creation] "is a process of integrating and transforming resources, which requires interaction and implies networks" [3], [7]. Therefore, we compare two modeling methods that show value creation through networks and interactions. For a number of years, the most prominent value-modeling method in the IS research has been $e^3$*value* [5]. However, there are other value-modeling methods, e.g., DVD [8], SEAM [9].

The $e^3$*value* modeling method has evolved throughout the years to represent the economic viability of a venture. The models capture networked industries of multiple actors who transfer value between each other. At its heart, $e^3$*value* draws its inspiration from the classic economics literature, to model the environment of an IS that is sustainable, meaning that it can produce monetary value.

SEAM is a method that helps modelers to represent how a network of suppliers provide value to a network of adopters and to itself, through collaboration, that results in a service system. SEAM is built on foundations that include general systems thinking, philosophy, policy making, service science, strategic thinking, software engineering, and enterprise architecture.

In this paper, we address the questions about (1) the commonalities and differences between $e^3$*value* and SEAM are for modeling value exchanges in the form of services, and (2) the modeling method a modeler should choose for their purposes. Considering that education is the primary field of application of both $e^3$*value* and SEAM, we seek to systematize and classify the modeling methods we show in our classrooms. We explore the feasibility of using the two methods together in this initial study and, through our comparison, we find that there is a sufficient overlap and some differences that would benefit further research. Students, future collaborators, and the research community could benefit from the different perspectives that these methods present and could be able to choose which method to use in which situation.

This is a joint work between the two research groups that created $e^3$*value* and SEAM. It began with the chance encounter of the authors, and then their willingness to compare and use together their methods. Our discussions resulted in reflections on what kind of models are used for value modeling, what choices modelers make when they use a modeling method, and which perspective a modeling method takes. We decided to formalize these reflections and to propose them to the research community.

In order to compare SEAM and $e^3$*value*, we model the same example with both methodologies. The example describes the international clearing of Intellectual Property Rights (IPR) for music broadcasting. We selected this case because it has been extensively used in $e^3$*value* research.

This paper is structured as follows. In Section II, we introduce an example used to compare both methods. In Sections III and IV, we introduce both methodologies and use them to model the example. In Section V, we describe a comparison framework, which we follow in Section VI to compare both methodologies. We discuss the comparison of the methods in Section VII. We present some related work in Section VIII, and we discuss the threats to validity for our study in Section IX. We conclude and give the outlook for future work in Section X.

## II. The Running Example

The public broadcasting of music (e.g., in cafes, radio, concerts) brings together four main entities. The rights user who plays the music, the rights owner who makes it available, and typically, two intermediaries. These intermediaries, called Intellectual Property Rights (IPR) societies, collect the fees from the rights users and distribute it to the rights owners. There are typically two IPR societies involved because each IPR society is based in a given country and collects fees for rights owners who reside in that country. If the music is played in a different country, the IPR societies of both countries are needed to perform the exchange of rights for a fee, much like fund exchanges between banks. The amount to be paid depends on the importance of music for the rights user and on the size of the audience. The fee, usually a fixed yearly fee, is paid by the rights users, giving them the right to play the music. IPR societies have a database of their rights owners, music tracks, and relations between rights owners; these relationships represent track ownership. The most important rights users (usually large radio and television stations) are required to report a play list. To understand which music is played where, IPR societies do market research in venues such as restaurants and shops. Based on this, a list of tracks is compiled, with the total number of seconds played and where. This aggregated play list is used to divide the collected money over the rights owners for a fair distribution. This process is called repartitioning. The case of public broadcasting is presented in detail in [10].

## III. SEAM

The most important elements of the SEAM ontology are given in the legend of Figure 1. The *business element* represents a service-providing value network. The business element can be seen as a black box or as a white box. If the business element is shown as a black box, the only other element it contains is a *service* (and its *properties*). A *service* is an interface for the value that an element provides where the external elements cannot see how the *service* is implemented internally. For a modeler to depict how the internal organization of a *service* is done (i.e., the transition from black box to white box), the *business element* can be refined through a *refinement* relationship. When the *business element* is shown as a white box, the model includes elements that comprise the value network that delivers the service, for example, business elements and human elements. These other elements participate with their *services*, through an *exchange* relation to the service *process*. SEAM has more provisions for value modeling: a supplier-adopter relationship model [11] and a motivation model [12]. Due to space limitations, these are not

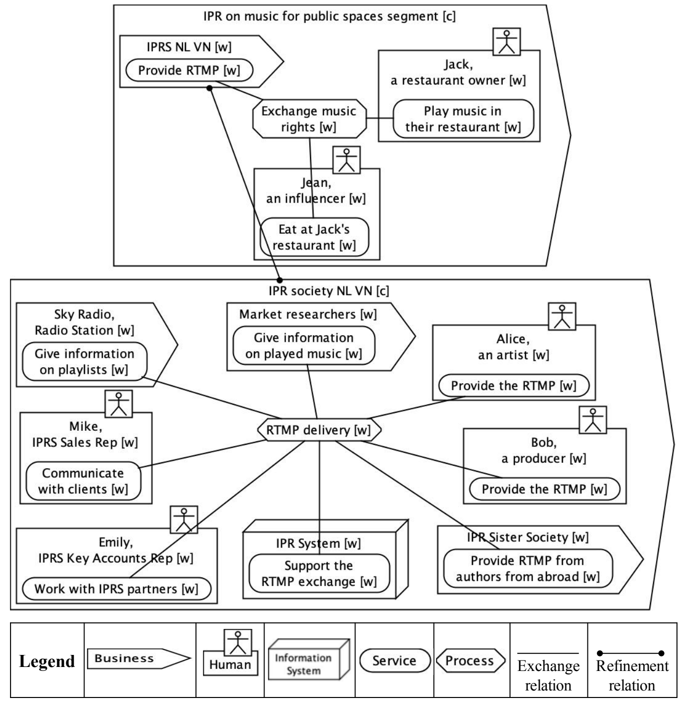


Fig. 1. SEAM service model of the IPR case

included in this paper. In our comparison, we use the SEAM behavioral model that most resembles $e^3$*value*.

Figure 1 depicts the SEAM service model of the case of intellectual-property rights. The model shows how the value network of the IPR society provides the service for the right-to-make-public (RTMP) music to its adopters. The service provider, the IPR-society value network (VN), and the service adopters (*the restaurant owner named Jack*, and *a customer named Jean, who eats at Jack's restaurant*) are shown on the first level. The IPR society participates as a black box (marked by '[w]' for whole) on the first level; the service adopters *Jack* and *Jean* cannot see how the IPR society organizes the delivery of the service of giving rights to make the music public.

On the first level, where the main service provider is modeled, the *exchange* relationship has semantics different than on the refined level. The *exchange* relationship represents a delivery relationship, and the elements on the right-hand side of the *process* element are considered adopters; these elements do not contribute to the *service process* but only consume the *service* of the service provider. The service adopters can be multiple, as shown in the case with *Jack* and *Jean*, and they are also considered when a motivational analysis is done. For example, the choices of *Jack* are going to depend on the preferences of *Jean*.

The second level shows the IPR society as a white box (marked by '[c]' for composite). The IPR society includes various actors who contribute with their services to the process of the RTMP delivery. The IPR society does not appear as a single business element in its own value network rather as multiple IPRS employees, *Mike* and *Emily*, who contribute to the RTMP process. The white-box element captures the IS that support the exchange of information between the different actors. The *IPR System* can be refined to smaller components, e.g., storage and libraries. The *Banks* are not present in the model because they are only a utility that helps in the transactions between actors but are not a defining feature of the service in making the music public.

## IV. $e^3$*value*

An $e^3$*value* model shows the *actors* or *market segments* (many actors of the same kind) involved, the *value* adding *activities* they perform, and the objects of economic value (called *value objects* they exchange via *value transfers*). Also, the notion of economic reciprocity is shown by the means of a *value interface*. The value interface contains *value ports* that represent that value object requested from or offered to the environment. The notion of economic reciprocity prescribes that if a value object is transferred via a port in a value interface, *all other* value ports in the same value interface should also transfer a value object, or no object at all. In the interior of an actor or a value activity, *dependency elements* are drawn. Various kinds of dependency elements exist: (1) the *customer need* represents that someone has a state of perceived deprivation [13], which can be satisfied by exchanging value objects with others. In other words, customer needs are satisfied by obtaining value objects from others. There are also *boundary elements*. These elements show that we are not interested in modeling additional value transfers. Customer needs, boundary elements, and value interfaces could be connected by three types of dependencies: (1) *straight* dependencies, (2) *AND* dependencies (all connected dependencies should occur), and (3) *OR* dependencies (some dependencies should occur). The $e^3$*value* is described in detail in [14] and is validated in many industries.

Figure 2 shows the $e^3$*value* model for the music case. A rights user (a restaurant) play a music track for their visitors. There are many restaurants, hence the use of the modeling construct 'market segment'. The restaurant needs to obtain the RTMP for the music. The restaurant pays a (yearly) fee, based on the function of the music (usually background music) and the size of the venue. The collection of the fees is done by the 'value activity' called *clearing*. All collected fees, minus a fee for the IPR society, are paid to another 'value activity' called *distribution*. The purpose of the distribution is to pay individual rights owners for their music. In practice, many tracks that are played have international rights owners. The fees collected for these tracks are paid to the international sister society who, in turn, pays the money to the rights owners. This is depicted by the transfers to the international sister societies and the transfers to the local distributing activity (annotated #1), thus separating the music played into national and international repertoires. There are two sources of revenue for the distribution activity: the fees collected by the national rights society and the fees collected by international sister societies for the repertoires that the national society clears. These sources of revenue are summed, indicated by

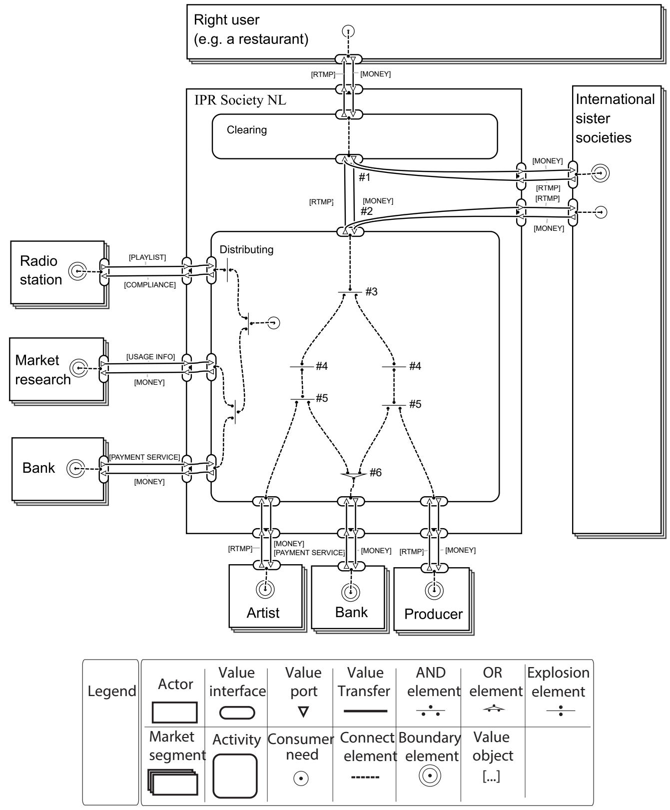


Fig. 2. $e^3$*value* model of the IPR case based on [10]

the OR join (annotated #2). The national rights society, in this case, clears the fees and distributes them for two types of rights owners: artists and producers. The fact that two types of rights owners must be paid is represented by an AND fork (annotated #3). A music track has multiple artists who are rights owners. This is modeled by an explosion element (annotated #4) that indicates that, for one track, *m* artists should be paid. The same construct is used to represent that a track can have multiple producers. In order to pay for both the artists and producers, the IPRS uses a payment service is represented by an AND fork (#5). The payment to either an artist or a producer triggers a flow to the bank, modelled by an OR join (annotated #6).

## V. The Comparison Framework

The comparison we propose is qualitative. We base it on the differences and similarities that we saw through the application of $e^3$*value* and SEAM to the example. The comparison framework is shown in Table I. We base the comparison attributes (*Users, Purpose, Language, Mapping, Origins, Application*) on the works of Thalheim [15], Gregor [16], and Gordijn [17].

Thalheim describes four main dimensions of conceptual modeling [15]: (1) *Purpose*: the relationship between the artifact (a model) and the primary reason for creating it, based on the work of Gregor on the nature of artifacts in IS [16]. We added three additional aspects about whether to and how to conduct a *context analysis*, whether the method could be used

TABLE I
COMPARISON FRAMEWORK BASED ON [15]–[17]

| Attribute | Choice | Description |
|---|---|---|
| User | Author (modeler) | Who is the modeler (active participant, observer)? Is it only one or many? How much knowledge specific to the modeling method do they need? |
| | Addressee | The models are created for a particular audience. Who are they? What is their purpose and motivation? |
| Purpose | Purpose based on Gregor's classification [16] | • Analyze: Creates a description of *what is*. No causal relationship or explanatory interpretations are given.<br>• Explain: Explains *what is, how, why, when, and where*. It relies on presenting multiple views of causality and of methods for argumentation.<br>• Predict: Not only describes *what is* but to also predicts *what will be*.<br>• Explain & predict: *Explains* in detail the phenomena and predicts what will happen. Provides testable hypotheses. Gives testable hypotheses about the future without thorough justifications or causality.<br>• Design: Gives guidance on how to build an artifact. |
| | Context analysis | Does it provide analysis tools for capturing not only the IS requirements but also the environment, e.g., stakeholders, their expectations, roles, economic situation? How does the modeling method present the context of the IS system? |
| | Individual / Group | Can the modeling method be used for creating a shared understanding between different people? How does the method present different perspectives? |
| | Type of analysis | What kind of analysis can be conducted with the modeling method: IS specifications, motivational analysis, socio-technical components and their interactions, and economic viability? |
| Language | Ontology | What information can be presented with the model, i.e., qualitative, quantitative, graphical, textual? What are the concepts in the ontology of the method? |
| | Other models | Are there more than one models in the modeling method? Are they connected and how? |
| Mapping | Reality to model | The modeling notation provides a way to map the relationship between the universe of discourse (an observed portion of reality) and the model. This is the epistemology of the modeling method. Epistemology provides the *User* with a means to express how they know what they know. A modeler has their own experience and value system that influence what they would represent in a model (captured by ethics). |
| | Model to reality | The model, or a part of it, serves as a basis for implementation of an artifact. How does the modeling method map the model to the reality to be created? |
| | Model to model | Different models have different elements that might not exist in other ontologies, or the same elements might exist but they might have different meanings. How are these model transformations handled in the modeling method? Are there already model-to-model mappings? |
| Origin | Known theories | Modeling methods use existing theories and knowledge from different domains. Hence, the modeling methods express a different world view distinctive for the domain it emerges from. |
| | Axiology | What are the choices that the modeling method adheres to? What are its aesthetics and ethics ? |
| Application | Tools | Is there a computer-aided tool to support the modeling process? Is it readily available? |
| | Adoption | Is the modeling method adopted in academic or industry communities? |
| | Value from using | How well does the modeling method model what it claims it can? How well does it achieve the purpose of its use? |

to achieve *individual or group understanding*, and what *type of analysis* can be carried out. These additional criteria were added based on our discussions and on the need to express our arguments for the reason of using the modeling methods. (2) *Language*: the ontology of the modeling methods can be used to discern what kind of concepts (entities and relationship) can be expressed with the modeling language. (3) *Mapping*: the relationship between the objects in the observed reality, the concepts of the observer, and the expressed representation (in the form of models) is based on the Ullmann's triangle of conceptualization [18]. (4) *Value* is evaluated based on the purpose and how well the models and the modeling method fulfill it.

We included also the *user* secondary attribute from [15]. Our reasoning was that the *user* dimension shows the targeted audience of a modeling method and how a modeling method accounts for the subjective dimensions of modeling. In addition, we chose two attributes, *origin* and *application*, to compare modeling methods from the work of Gordijn [17]. In the work of Gordijn et al., the authors are also the creators of the modeling ontologies and used these two attributes to present the differences and similarities, based on their own understanding of the modeling methods. We included the *value* dimension of Thalheim [15] under the *application* attribute because it reflects how well the modeling method fulfills the *purpose*, or how well the models describe the situation under observation.

## VI. COMPARISON

### A. Users

*1) SEAM:* SEAM requires the modeler to understand the relationships between groups of people in different contexts. In the example, the SEAM diagram shows together the restaurant owner and the person who eats at the restaurant. The modeler needs to understand the environment of the service, often the modeler has the role of a business analyst, an RE practitioner, or a consultant. Also, modeling with SEAM requires some specialized knowledge of its *language*. An addressee of a model can be the modeler(s), someone who is engaged in the service exchange under modeling, or someone external. Most often, the modeler uses the model to understand the context and to be able to find ways to integrate an IS that fits in this context. In this sense, the immediate addressee is the modeler but, at the end, it is the stakeholders who benefit from the results of the modeling.

*2) e$^3$value :* The general purpose of *e$^3$value* is to understand the context of service systems and, especially, their *raison d'être*. The intended user of the *e$^3$value* method is first the business developer, the analyst, or the consultant. These users need to have good conceptual modeling skills and be educated in the methodology. Other users are members of the board of directors, people responsible for innovation in a company, and the marketers. Usually, these people read and comment on the *e$^3$value* model but are not directly involved in technically constructing the models. In this case, we played the role of model builders, where people at the management level (of the IPR society) commented on the models so that we could improve them.

*3) Commonalities:* Both methods focus on the *context* of service (information) systems. Although we agree it is important to understand the IS requirements, it is also critical to understand *contextual requirements*. In our experience, misunderstanding the context could hinder requirements engineering process. Our experience is that modeling is perceived as *difficult* by users, and that they need coaching. There are method that are easier to understand, e.g., the Business Model Canvas [19]. As they favor simplicity, such methods lack rigorous analysis support.

*4) Differences:* The *e$^3$value* has a focus on the notion of *economic value*. Hence, it opens up the possibility to develop analysis tools, such as net-value and fraud analysis. But these rigorous analyses require expertise in using the method. Consequently, these methods are less frequently adopted. Whereas, SEAM is more *generally applicable*, which makes it versatile. But the lack of a particular domain makes it difficult for users (especially practitioners) to apply it to their context.

### *B. Purpose*

*1) SEAM:* The SEAM model is created to *explain* how the service exchange between the IPR society and the restaurant is done, and how the IPR society is organized internally in order to deliver the service. If the model is seen only on the first level, then the purpose would be to only *analyze* what the situation is, without going into the details of how the service delivery is achieved. We can observe this for the radio stations that are in the value network of the IPR society. The IPR receives the services of the radio stations but does not see how the stations' value network is organized. The SEAM model can include this level of detail, but the modeler can decide not to include it, based on whatever reason they create the model for. The model also shows which IPR society employees are involved in the value exchange, instead of using abstract generalizations about the IPR society. Hence in the diagram, we can observe the roles of people who would correspond to the responsibilities in the value exchange process.

The SEAM model also shows the IS that supports the service exchange. This means that SEAM could be used to elicit, document, and communicate IS requirements. By building the SEAM model, the IPR employees and their partners can build a shared understanding of how to work in order to deliver the RTMP to their service adopters and how an IS would complement the process.

*2) e$^3$value :* We could use *e$^3$value* for many purposes. Originally, the method was intended to assess whether companies can be financially sustainable in executing a service. Many model elements can be quantified, e.g., the number of restaurants, the number of music tracks they play, the fees they pay. If all required elements have an appropriate quantification, we can generate net-value cash-flow sheets for each actor. All actors should have a positive net-cash flow in order to be sustainable. Before the generation of the net value, model checking can be done, e.g., checking if each value transfer has an economically reciprocal value transfer (e.g., RTMP for money). Another purpose is to have a shared understanding of the commercial aspects of the service to be developed. In the music case, the purpose is to derive meaningful process models (in BPMN) that put the *e$^3$value* model into operation, or to separate the WHAT (*e$^3$value* ) from the HOW (BPMN).

*3) Commonalities:* Both methods are used primarily for *explanatory* purposes. As typical applications always involve multiple stakeholders, in order for a shared understanding to emerge, there is a clear need to explain the service system to the stakeholders. Both methods can be used for building alignment among stakeholders by creating the models in a group and by expressing explicitly how involved parties see the situation.

*4) Differences:* *e$^3$value* focuses on interactions, in terms of *economic value* transfers, between enterprises and end-users. Also with *e$^3$value*, we can create testable hypotheses on the profitability of a venture. With SEAM we consider interactions to represent a generic construct. Actors' values are derived in the service exchange as *subjective perception*. Furthermore, SEAM provides a means to describe the desired behavior of an IS from the actors' points of view, hence SEAM can be used to design an IS. Thus, SEAM's purpose revolves around analyzing and designing socio-technical systems.

### *C. Language*

*1) Ontology comparison:* In Table II, we present the concepts of the two ontologies. In the table, we separate the ontological elements into four logical groups. The first section presents the concepts that the modeling languages use for actors. The second section holds the value-modeling elements. The third presents the relationship elements that show the composition of elements. The fourth section presents the start/stop elements for value exchange.

We see from this side-by-side element comparison that SEAM has more specialized elements for describing the internal parts of a system. SEAM's *business working object* has the semantics of the three actors of *e$^3$value*: (1) *elementary*, (2) *composite*, and (3) *market segment*. SEAM's ontology can be used to describe humans, IT working objects, components of an IT working object, and storage elements. One important difference is that *e$^3$value* does not have an information-system element.

TABLE II
ELEMENTS FROM THE ONTOLOGIES OF *$e^3$value* AND SEAM

| Groups | *$e^3$value* | SEAM |
|---|---|---|
| Actors | Actor<br>Elementary actor<br>Composite actor<br>Market segment<br>-<br>- | Working object<br>Business working object<br>Human working object<br>IT working object<br>Component working object<br>Storage working object |
| Value elements | Activity<br>Value interface<br>Value port<br>Value object | Distributed action (process)<br>Localized action (service)<br>Localized property<br>Distributed property |
| Relationships | Connect element<br>Value transfer<br>AND element<br>OR element<br>Explosion element | Refinement relationship<br>Exchange relationship<br>-<br>-<br>- |
| Start/Stop | Consumer need<br>Boundary element | -<br>- |

The way that *$e^3$value* and SEAM represent value differs as well. The *$e^3$value* ontology offers a *value object* that is exchanged via a *value port* and a *value interface* to a *value activity*. The composition of interfaces in *$e^3$value* is handled with different relationship elements (logical AND and OR operations). In SEAM, the value exchange is modeled with distributed actions (called processes) and localized actions (called services). The composition of activities in SEAM is handled with hierarchical structures via the *refinement relationship* with either different distributed actions or nesting sub-distributed actions.

To show the logical start and end of a model, *$e^3$value* has the additional elements. The *consumer's need* element represents the entry point of a diagram. The *boundary elements* represent the end of a model.

*2) SEAM:* SEAM includes a formalized ontology for modeling hierarchical service-systems [20], [21]. The entities in the ontology are working objects, distributed and localized actions, as well as localized and distributed properties. The ontology represents a systemic modeling language that presents objects in relation to other objects with either (1) a hierarchical relationship between a process that implements a service exposed as an interface to the higher hierarchical level, or (2) a service that the objects expose to the other elements on the same level.

SEAM also includes graphical qualitative models that are a visualization of the formalized service ontology. The example shows how a SEAM behavioral diagram looks. The model is conceptually divided in two parts to present (1) the service exposed by the IPR society to their service adopter, and (2) the implementation of the service by the value network of the IPR society. The graphical elements present the hierarchical nature of the service delivery. SEAM has a service-oriented language; it includes terms such as a service adopter, a service provider, a service exchange, and a value network. SEAM uses terms from the broader computer science vocabulary: white box/black box view, service implementation, pre- and post-conditions, etc. Hence, with SEAM, a modeler is able to express a situation in a service-oriented way.

The SEAM family of models includes models for capturing behavior and analysing motivation. Here, we present only a behavioral model that depicts how the IPR society works with their partners to deliver a service to the service adopter, the restaurants. Other models that we could have included are a motivational analysis model for depicting the goals and beliefs of the different actors [12] and a supplier-adopter relationship model for expressing the connection between service properties [11].

*3)* $e^3$value *:* There is an ontology for the *$e^3$value* methods, expressed in RDF/S, Prolog, and Java. The most important model elements are expressed in Section IV. We deliberately chose a graphical language to enable easy communication between stakeholders. In order we can generate net-value flow sheets, most model elements can be quantified financially. An *$e^3$value* model expresses mostly intentions. For example, we modeled the the restaurant's intentions: to obtain and to pay for the RTMP. More precisely, an *$e^3$value* model describes a perfectly honest world: if someone obtains a service they will always exchange something in return. Behavior is not modeled by an *$e^3$value* model. For example, an *$e^3$value* model does not have a notion of time ordering. In this example case, we cannot derive that the artist has to provide the RTMP before the RTMP is provided to the restaurant. The only notion of time in an *$e^3$value* method is the contract period: the period of time the model covers, for instance, one year; hence, the generated net-value flow sheets are generated for one year.

*4) Commonalities:* Both methods have both a *graphical* language and a meta-model. Both methods have formal requirements with respect to the internal validity of the models, expressed by their respective ontologies. This sets, *$e^3$value* and SEAM, apart from most of the other approaches in the business world; these approaches are often natural text-driven or structure the domain in only a few quadrants. The advantage is simplicity (hence a method is usable by everyone), but the disadvantage is imprecision, vagueness, and insufficiency for further rigorous (automated) analysis.

*5) Differences:* The *$e^3$value* method relies on the *quantification* of many elements (e.g., customer needs, number of actors, prices to be paid). SEAM is a *quantitative method*. The *$e^3$value* speaks a *commercial language*, and, coincidentally, many value object in *$e^3$value* are in fact valuable outcomes of services. Whereas SEAM speaks a *service-oriented language*.

## D. Mapping

*1) SEAM: Reality to model:* The relationship between the observed reality and the SEAM models is influenced by the work of Cooper et al. on designing with prototypical personas [22]. A SEAM modeler has to take one concrete representative example of a service adopter. In the SEAM model of the example, the restaurant owner is called Jack. A modeler has to collect information by observing and talking with Jack about what Jack wants, needs, and provides in the service exchange, etc. This technique of using a concrete example, provides a rich data-source that needs to be mapped later to the models by mapping observations and model elements.

*2) $e^3$value: Reality to model:* The $e^3$*value* modeling language comes with practical guidelines on how to create an $e^3$*value* model, along with a series of workshops that can be conducted with stakeholders. Example guidelines are (1) that each value transfer needs a reciprocal transfer, (2) that a value object should be of economic value for at least one actor in the model, and (3) that many actors that assign economic value in the same way are a market segment.

*3) SEAM: Model to reality:* In the SEAM family of models, there is no explicit mapping between the models and the artifact that will be constructed based on the models. The models are used by stakeholders primarily for communicating the service exchange process and negotiating features of the services they need in order to deliver their own services. The SEAM service model can be used for constructing an information model for the corresponding services, but this information modeling is not a standardized step in SEAM. This model-reality traceability is an open area for future research.

*4) $e^3$value: Model to reality:* The graphical models are a vehicle for stakeholders to discuss whether the model corresponds to reality. Yet, we experience that many stakeholders need time to correctly interpret the models. Therefore, we currently explore the use of cartoons to simplify this process.

*5) SEAM: Model to model:* The refinement between models has also been studied and includes model transformations and mapping among a motivational model, the supplier-adopter relationship model, the information model, and the behavior model. SEAM has also been mapped to an enterprise architecture method [23], [24]. Current work includes a method and a tool for mapping web-service specifications and service models [25].

*6) $e^3$value: Model to model:* The $e^3$*value* model is a point of departure for other models. First, we can drop the requirement that an $e^3$*value* model describe a perfectly honest world, and we can enable states where actors misbehave, for example, playing music in their restaurant without paying for it. We call such models sub-ideal models. To explore all kinds of cases of fraud, they can be (automatically) derived from the ideal models. Second, the $e^3$*value* is usually the point of departure to designing a process model, e.g., by using the BPMN. We have several guidelines how to do so [10].

*7) Commonalities:* Both methods have *heuristics*, although different, to build the models. These heuristics are necessary because the relationship between reality, observer, and the model is intricate, and because only by subtly understanding the mapping, a modeler can draw benefits from the methods. Both methods include more than one model in their family of methods. The models presented in the paper are used as stepping stones in the construction of other models derived from the service models.

*8) Differences:* SEAM includes heuristics for building information models used for the development of IS. Most SEAM models are used as initial steps in building the understanding of what an IS will do for the service system. $e^3$*value* is mapped to procedural models, e.g., BPMN.

### *E. Origins*

*1) SEAM:* SEAM stands for the Systemic Enterprise Architecture Method. SEAM is a systemic method that emerged from software engineering, general systems thinking (GST), enterprise architecture, and service science. The catalysis approach was an inspiration at the time of the creation of SEAM [26]. Many of the foundational concepts are interpretations of the components of catalysis, i.e., distributed and localized actions, and declarative language. In its graphical notation, SEAM is heavily influenced by software engineering, which explains the schematic similarity with UML and other engineering modeling methods. SEAM relies on notions from GST where a service can be seen as a system, or a set of interrelated elements [27]. GST is a meta-discipline and it assumes a philosophical standpoint for connecting the other disciplines. GST is thus domain-agnostic, which explains the choice we made in designing SEAM to not focus on a single domain. In its genesis, SEAM was an enterprise architecture method, hence it was vital to present the layers of an enterprise and the place of different components in these layers. This explains the hierarchical structure of the SEAM models.

*2)* $e^3$value *:* The $e^3$*value* modeling technique was based on the value-chain theory of Porter [4], then later on the theory of value webs and constellations [28], [29]. $e^3$*value* is closer to the idea of a network [28] or a web [29], this enables different structures with respect to relationships (rather than only linear chains). $e^3$*value* is based on standard textbook literature on marketing [13] and accounting [30], [31], and on the theory of economic value, also called axiology [32].

*3) Commonalities:* Considering their way of working, both methods use the approaches followed in requirements engineering and software engineering. In terms of content, both methods use some constructs from existing modeling methods, although with slightly different meanings.

*4) Differences:* $e^3$*value* relies on the (standard) business literature. SEAM is built upon notions from GST and service science. Although there is some overlap in practice, the point of departure is different. $e^3$*value* is more pragmatic, whereas SEAM is more philosophical.

### *F. Application*

*1) SEAM: Tool support:* In the SEAM ecosystem, there are two CAD tools that support service design: seamCAD (available to the public) and TradeYourMind (proprietary). seamCAD was developed as a part of the research agenda of our research group. It is currently being extended with the tool for REST API generation. TradeYourMind was developed in collaboration with an industry partner who wanted to use SEAM in their projects. Also, we are currently developing a new tool for both visual and textual editing.

*2) $e^3$value: Tool support:* There are currently two software tools available for $e^3$*value*. One tool is a reference tool that implements the full language, the other tool is a partial implementation of the language that focuses on the generation of fraud scenarios. Around one year ago, to bring the methodology to the market, we started a company, The Value Engineers[1]; part of this venture is to build an enterprise-grade tool for the complete methodology.

*3) SEAM: Community adoption:* SEAM emerged from the academic community and is now used for teaching and in consulting. However, SEAM's adoption by the industry or other communities is limited. As a systemic modeling method, SEAM is flexible and can be used in many contexts. This flexibility is also a drawback because SEAM is a domain-agnostic modeling method, hence and adopters have to adapt the modeling to their domain. From our experience, if facilitated by a SEAM expert, SEAM can be successfully used by business analysts for elicitation of requirements in workshops. The popularization of SEAM has proved to be a challenge, consequentially we are experimenting with videos, cartoons, tutorials, and books to explain SEAM to a broader audience.

*4) $e^3$value: Community adoption:* In the research community, *$e^3$value* is well-known and often used in many disciplines, both in national and international (EU funded) projects by ourselves (the creators of the method), as well as by others. With the aforementioned startup, we now work on bringing *$e^3$value* to the industry and, more specifically, practitioners. We consider this to be the final step in the validation of the methodology; the first step is to have a methodology adopted by researchers, and the second step is for (many) practitioners to consider the methodology useful.

*5) Commonalities:* Both methods are used for research and teaching. Both methods were, to a limited extent, adopted by practitioners. Both methods provide tools for designing models and are developing new ones. It is difficult for users to grasp the usefulness of the methods because of the intangible results that they provide: building a shared understanding and communication.

*6) Differences:* The most significant difference in the application of the two methods is their adoption by the scientific community. *$e^3$value* is a widely recognized and used method in academia, whereas SEAM is not used by a large set of people. *$e^3$value* has been used in commercial projects where it was evaluated on its usability and usefulness by practitioners (cf. [33], [34]).

### G. Summary

Table III shows a summary of our findings. The features listed in the table can be used when either SEAM or *$e^3$value* are considered for modeling value. The table shows that the two methods are similar more than they are different. Both have a graphical language, originate in software and requirements engineering research and teaching, and while building a common understanding among modelers, they seek to provide explanations of a value-exchange situation. The differences lie mainly in their underlying philosophy. *$e^3$value* is oriented toward the quantitative modeling of point-to-point economic, or monetary, exchanges with an objective view of reality. SEAM is oriented toward the subjective, qualitative co-creation of either monetary and non-monetary values, with an emphasis on the notion of service as a way to abstract the intricacies of this co-creation.

[1] https://www.thevalueengineers.nl/tools/

TABLE III
FEATURES OF THE MODELING METHODS BASED ON THE COMPARISON

| Dim | Feature | SEAM | $e^3$value |
|---|---|---|---|
| Users | Need coaching | ✓ | ✓ |
| | Addressee | Modeler | |
| Purpose | From [16] | Explanation | |
| | Context analysis | ✓ | ✓ |
| | Stakeholders' alignment | ✓ | ✓ |
| | Type of analysis | Socio-technical networks analysis | Economic viability |
| Language | Graphical | ✓ | ✓ |
| | Formally specified | ✓ | ✓ |
| | Possible analysis | Qualitative | Qualitative & Quantitative |
| | Concepts | Service-oriented | Economic |
| Mapping | Heuristics for modeling | ✓ | ✓ |
| | Many models | ✓ | ✓ |
| | Model transformations | motivational analysis, IS specifications | BPM, motivational analysis |
| Origins | SE/RE method | ✓ | ✓ |
| | Foundations | Service Science | Business and economics |
| Application | Primary domain | Research and teaching | |
| | Practitioners community | small | small |
| | Tools | ✓ | ✓ |
| | Well-known in academia | | ✓ |
| | Evaluation of use | | ✓ |

## VII. DISCUSSION

*$e^3$value* and SEAM can be seen as coming from similar yet slightly different traditions. Both methods have their roots in the software engineering tradition of graphical models that represent a future system's environment that is software-based [35]. The main difference between the two methods is their philosophical underpinnings, i.e., the continuum between Soft Systems Thinking (SST) and Hard Systems Thinking (HST) [36]. Soft Systems Thinking (SST) is close to the interpretivistic school of thought. Interpretivism considers that objective reality per se does not exist, whereas the interpretations of the observers of a system do exist. These interpretations depend on who the observers are. Furthermore, SST is mainly concerned with fuzzy, ill-defined problems that organizations have, and with ill-structured, technical problems [37]. The philosophical discussion on the differences and similarities, as well as on the application domain of the different streams of GST literature, is present in the literature (cf. [36], [38]). In line with our comparison, in the music rights example, we see how both *$e^3$value* and SEAM adhere to the philosophy of SST: Both methods could be used to model different perspectives and to construct a vision of the reality as it is or as it will be.

On the other end of the spectrum is Hard Systems Thinking (HST), from the positivistic school of thought. HST has its roots in [technical] systems engineering. As such, in HST the systems under consideration exist in reality and are independent of the observers. With HST, the modeler can capture the laws that govern the dynamics of the system, i.e., rates, explicit relations that are expressible in the form of formulas. For our comparison, we believe $e^3$*value* exerts some traits from the HST school of thought. An $e^3$*value* model can capture financial dependencies and conduct an analysis of the economic viability of a system.

SST models are *representations* of *an observed portion of the reality*. These representations are potentially different for each observer, meaning that the models are not simply different representations of the same interpretation of reality, but that these interpretations of reality (called the conceptualization in SEAM [39]) are different for each observer. HST models are *the direct representation* of *the reality*. Observers are expected to share the same reality, even if their models differ somewhat.

Value is an elusive concept with a philosophical origin that is complex to define. This is apparent in the two methods, in their treatment of the concept of value. In our case, $e^3$*value* and SEAM have two interpretations of what value in IS is and of how to model it. $e^3$*value* was created shortly after the burst of the dot-com bubble; our main inspiration at that moment was to evaluate electronic-service ventures before they went to the market. The focus of the $e^3$*value* evaluation is on how *viable* a service is and not on how *valuable* it is in some absolute sense. The $e^3$*value* models help service designers create economically sound systems. However, this classic economic definition of value can exclude actors and relationships that do not contribute to the economic rationale of breaking even.

In SEAM, value is defined loosely as the benefit that a service adopter receives from [the features of] a service. This broad definition includes economic benefits but with it we mainly aspire to model how an actor contributes to and how an adopter benefits from the service. The downside of such a definition of value is that it is strictly subjective and dependent on both the modeler and the other people, who project what valuable means to them, involved in the model creation.

In our comparison, it became apparent that the nature of value is the culprit for the differences in our modeling choices, and that there is at least a dual definition. Nevertheless, the value definitions of the two methods are not mutually exclusive. The definition of service-science value is not contradictory to economic value. Service science separates value into value-in-use and value-in-exchange [2]. Economic value represents value-in-exchange, and service interactions represent value-in-use.

We believe it is useful for modelers to understand the definition of value; this stands at the core of a modeling method. By knowing how a modeling method "sees" value, a modeler would be able to choose a tool for analyzing the IS environment in an informed manner.

We also believe that such a comparison helps designers to understand better the methods that we created. This refined understanding helps us to teach and to improve them. The end goal for both research groups is to be able to better explain their method and to help others adopt it for reasoning about IS development.

Our motivation for comparing the two methods was also related to our curiosity about why both methods have closely related notions (e.g., value networks, services, and exchange) yet still slightly differently represent the world. This similarities led us to believe that the two methods could be used together. For instance, SEAM models explicitly an IS and the value it brings to the value network, whereas $e^3$*value* represents market dynamics. These two complementing features make it interesting to explore how to comprehensively model together a scenario and how to enrich each of the methods with additional concepts.

In a socially constructed world, maps create a territory [40]. Hence, a certain language from a modeling method leads modelers to observe the phenomena that the language has in its ontology. For example, $e^3$*value* has the notion of reciprocal value transfer that prompts modelers to look for this kind of relationship between actors. SEAM has the notion of a service-delivery process that prompts modelers to focus on the contribution of a set of actors to the service, rather than on the way they are rewarded in exchange for their participation in the process.

The different vocabularies of the two modeling languages enable modelers to *see* different parts of the reality and can blind them to other parts. This helps to understand what portion of the reality we are looking at when using $e^3$*value* or SEAM.

## VIII. Related Work

We present three lines of research related to our study: (1) comparing modeling methods to show differences and similarities, (2) comparing modeling methods with the purpose of relating and showing how to use them together, and (3) comparison frameworks for comparing at scale. We show a representative sample of the field of modeling method comparison.

### A. Comparing Methods to Show Differences and Similarities

Previous work in comparing modeling methods includes the work of Souza and his colleagues who compare their own Dynamic Value Description (DVD) method with $e^3$*value* [41]. Their comparison is an qualitative study of three experiments conducted in three countries on how the two methods were being used by students. Their work does not, however, discuss the qualitative characteristics of the methods, how they can be used together, and how to choose a modeling method for a particular purpose.

$e^3$*value* has been compared with the Business Model Ontology [17]. Their study shows how $e^3$*value* and BMO compare on an ontological level. Their work was an inspiration for this paper, and we used parts of the comparison framework. In this paper, we extend the comparison to include not only the ontologies of the methods in question, but also other philosophical aspects that accompany the use of a modeling method.

### B. Comparing Modeling Methods to Use Them Together

$e^3$*value* has been related to the *i** modeling method and to how the two of them could be used together [42]. The work describes how an integration of the two methods is possible, is beneficial, and gives some guidelines without formalizing the integration or the comparison.

Similar studies include the work of Caetano et al. on integrating the BMC, $e^3$*value*, and the business layer of ArchiMate [43] and two previous studies on integrating BMC and ArchiMate [44] and $e^3$*value* and ArchiMate [45] on a meta-model level. These comparisons relate mostly the ontologies of the modeling methods and give semantic interpretations to the different elements of the ontologies that present similar or the same concepts. The comparisons are not structured but guided only for the purpose of relating the meta-models.

The SEAM method emerged from the field of enterprise architecture and is compared to Zachmann's enterprise architecture framework [24]. The primary motivation of the authors was to show the value of concreteness in enterprise architecture. The result of their work explains how to use SEAM inside Zachmann's framework.

### C. Comparing on Scale

There are multiple studies on how to compare modeling methods on a larger scale. Here, we mention the studies of Andersson et al. [46], Lambert [47], Pfeiffer and Gehlert [48], Jasper and Uschold [49], D'Souza et al. [50], and Pateli [51] on how to analyze conceptual models and how to analyze business models. All of the above-mentioned works present, either as a by-product or as a main artefact, structured frameworks for analyzing the elements of a modeling method.

For example, Andersson et al. use three modeling methods to define a reference ontology for business models that can be potentially used for a model comparison of other methods [46]. The works of Jasper and Uschold [49] and Pfeiffer and Gehlert [48] take another approach for comparing conceptual models that help automatically or semi-automatically relate concepts presented with different elements in the ontologies. The two studies focus only on the ontological level of the modeling methods under consideration.

Lambert presents an analysis framework with three generic attributes (level of analysis, unit of analysis, conceptual focus), but the framework has a limited application for detailed comparisons due to its generic nature [47]. Pateli and Giaglis also give various criteria based on an extensive literature review for analyzing business models [51]. Their framework lacks, most notably, the users and the purpose dimensions for comparing modeling methods. D'Souza et al. present a thorough framework for analysis viability in business modeling methods [50]. However, their work is focused only viability and is unsuited for comparison of models for different purposes.

## IX. Threats to Validity

We consider certain threats to the validity of our comparison. First, we use a historical example for comparing the two methods. This passive modeling example might threaten the validity of the models created with $e^3$*value* and SEAM. However, the example is based on a case study that the second author has conducted, modeled with $e^3$*value*, and presented previously (cf. [10]). Thus, the $e^3$*value* model in this paper has been validated. Subsequently, we question of the quality of the SEAM model. Given that the second author conducted the case study, he was able to provide us with various details. In this paper, we use the example to simply illustrate the expressive powers of the two modeling methods. We do not attempt to validate usability or usefulness of the created models for practitioners. We strive to create models that show the strengths and weaknesses of the modeling methods for our discussion.

The next threat to the validity of our comparison is that the creators of the modeling methods under comparison are the authors of this paper. The threat comes from the intimate relationship that the creators have with their creations: we risk having biased opinions. Nevertheless, the creators of the modeling methods are an incomparable source of information. Creators are able to provide details of the most intrinsic properties of their methodology and to justify the modeling choices that have to be made using their method and the history of the evolution of their modeling methods. For our purpose, to qualitatively compare $e^3$*value* and SEAM, this source of information proved to be vital, even if it is not easily reproducible. When the methods are openly described in the academic literature, it is possible to compare modeling methods without the creators being involved in the comparison, which is the case for both of these methods.

We must mention one last threat to the validity of our study that is related to the comparison framework we use. The comparison framework is not validated in its current form. However, our purpose for using a comparison framework is to structure and guide our discussions, and not to produce a complete and comprehensive comparison framework with this paper. We also rely on the fact that our framework is largely based on already known published research.

## X. Conclusion and Future Work

In this paper, we have presented a comparison of two value-modeling methods, SEAM and $e^3$*value* ; we have developed them during the last 20 years. The results we present only scratch the surface of how to compare and combine the two methods. This paper provides an exploratory study for answering the question about if SEAM and $e^3$*value* have sufficient overlap: to which the answer is 'yes'. One path to explore is how to combine $e^3$*value*, a classic value-modeling method, with SEAM, a service-oriented value-modeling method that is closer to IS development.

We created a comparison framework, which we extended from existing literature, and we applied it to both methods. The results we present here can help researchers, educators, and even practitioners to select the method that best matches their needs. Having accomplished this work, we realize that the main field of application of both methods is education. Education is a special case because, as it is concerned with learning rather than with implementation, it allows for the simultaneous use of several methods. In this case, our results can be used for courses that include value modeling. The work on the comparison framework is preliminary, and we intend to extend, formalize, and apply the framework to other methods as well. We would also like to extend our work towards comparing different models from the same modeling method and comparing multiple models from one modeling method with multiple models of another modeling method. We envision to collaborate further in order to integrate the two methods based on the results presented here.

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