Quantitative, Value-driven Risk Analysis of e-Services

ABSTRACT

Modern e-services are provided by networks of collaborating businesses. However, collaborators, and even customers, don't always behave as expected or agreed upon, and fraudsters aim at unfair exploitation, legally or illegally. Profitability assessments of e-services should therefore look beyond revenue streams and also consider threats to the financial sustainability of the service offering. More importantly, any such analysis should consider the business network in which the e-service is embedded.

The *e³value* method is an established modelling and analysis method which allows enterprises to estimate the net value flows of a networked e-business. Recently, the method and its ontology have been extended to cover aspects related to risk, e.g. fraud. In this paper, we introduce four new software-enabled risk and sensitivity analyses, which build upon this extension. The techniques are quantitative and therefore support making motivated risk mitigation decisions. We illustrate them in the context of three realistic case studies.

Keywords: e-services; value modelling; profitability estimation; risk analysis, fraud.

INTRODUCTION

Today's economy consists mainly of services, for the developed countries usually larger than 80 percent (see http://www.bls.gov/fls/flscomparelf.htm for an overview). Increasingly, these services are offered by a *constellation* of enterprises rather than just one. For example, broadband Internet access often requires two enterprises: one that provides the raw bandwidth and one that provides services like email, voice over IP, and traffic routing. An important

requirement during service development and deployment is that each enterprise in the service can sustain economically. Therefore, the potential expenses and revenues of a service should be carefully evaluated before making the service available to customers. One established way of obtaining an initial indication of economic sustainability is value modelling. Value models take an economic perspective by depicting the transfers of economic value that take place between the actors involved in the provision and consumption of e-services in a *value constellation*. A value constellation is a network of actors who collaborate to produce value with each other (Norman & Ramirez, 1993), or to create value for customers and wealth for their stakeholders (Tapscott, Lowy, & Ticoll, 2000). They abstract away from technical and even procedural considerations in order to provide an understandable high-level representation of relevant actors and commercial transactions. This allows economic assessment of a business network without being distracted by the complexity of coordination procedures or IT architectures, especially in its early stages (Weigand, 2016).

The *e³value* approach to business modeling (Gordijn & Akkermans, 2001) (Gordijn & Akkermans, 2007) takes a purely economic perspective, is based on a well-defined enterprise ontology and comes with a graphical tool. It produces a quantitative net value flow estimate, is understandable to stakeholders and takes a constructive approach to value modelling. However, the *e³value* tool only supports one type of analysis, namely discounted net cash flow analysis. Also, *e³value* does not assess the potential risks associated with a value model. It assumes that all economic transactions specified in the business model will occur as specified and that all actors behave as promised. This is a reasonable assumption in the early phases of business development since at that point in time, the focus should be on who offers what to whom (the so-called value

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proposition) only. However, once the service is deployed, actors may behave as promised, or they may even attempt to commit fraud.

Sensitivity and risk analyses are needed to assess the financial sustainability and resilience against falsification of these idealizing assumption. The ability to improve the service delivery process in terms of the value it creates and transfers can further empower these analyses.

In this paper, we describe and illustrate new quantitative analyses techniques and supporting software tooling to deal with these problems. The extensions allow software tool-supported (e^3tool) sensitivity analysis, automated generation and ranking fraud scenarios, as well as assessing the financial sustainability of business coordination processes. In the next two sections, we introduce the e^3value and e^3fraud ontologies, and we describe our research methodology. Next, we describe four types of financial analyses and their inner workings:

- discounted net cash flow analysis of e^3value and e^3fraud models,
- sensitivity analysis,
- fraud analysis, and
- sustainability analysis of business coordination processes.

In the Case Studies section, we apply combinations of these analyses to e-service design and assessment in three different business domains in order to solve a variety of business modelling and risk analysis problems. Finally, we draw conclusions with regard to the applicability of these techniques in the accounting domain.

BACKGROUND

Value Modelling

Value (co-creation) modelling is used to show that a business model involving multiple parties in a value constellation is profitable (Gordijn & Akkermans, 2001). Value models

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abstract away technical and operational aspects of a value constellation, such as IT architecture and business coordination processes, and focus solely on representing creation and exchange of economic value. As such, value models are used whenever assessing the profitability of a planned or existing business network is a critical success factor, such as during service innovation or re-engineering (Weigand, 2016).

Three established approaches to value modelling are (1) the Business Model Canvas (BMC) (Osterwalder & Pigneur, 2010), (2) the Resource / Event / Agent (REA) ontology (McCarthy, 1982) and (3) e^3value (Gordijn & Akkermans, 2001). The BMC take the viewpoint of a single enterprise and regards the other entities (e.g. suppliers and customers) involved as third parties. It does not treat all participants in a value constellation as equal citizens and does not support any formalized analysis technique, including profitability assessment. REA and e^3value were both designed to capture exchanges of economic resources which occur in a network of economic actors (Weigand & Jeewanie, 2009), such as services, products or money. The two ontologies share strong conceptual similarities and a direct mapping is possible (Andersson, et al., 2006). However, REA was developed with accounting applications in mind, whereas the first goal of e3value is the design of networked value constellations for business development. Furthermore, e3value allows for quantification of revenues and expenses as a result of customer needs, and software supported analysis of these financial figures. Therefore, we opt for e^3value as the value modelling ontology of choice.

e^3value

In e^3value, a networked value constellation as it exists in a period of time, called the *contractual period,* is described in terms of *actors* which exchange *value objects* via *value transfers*. FIGURE 1 provides an overview of the most important concepts of e^3value and their

graphical representation. Actors may be profit-and-lost responsible organization units, businesses, customers, suppliers, business partners, government organizations, etc. Examples of value objects are e-services, physical products, knowledge, experiences, and money. The key notion here is that a value object should be of economic value to at least one of the actors in the constellation.

Value transfers can be grouped into *economic transactions* such as purchases, exchanges, or trades, which behave atomically from a commercial point of view. In short, this means that either all transfers in a transaction happen in the contractual, or none of them. This models the notion of economic reciprocity of a transaction: goods or services are provided in return for something of similar value, often money. Incomplete transactions cannot occur by definition in value model.

Transactions in turn are chained together using *dependency paths*. These paths are triggered by *consumer needs* (e.g. need for a service, desire for a product). To satisfy a consumer need, all transactions on a dependency path must be executed.

It is important understand that dependency paths model causal relations: if a need occurs in a contractual period, a set of connected transfers must occur also in the same contractual period. By no means do these paths model time-ordering, as common in process-oriented models such as the Business Process Model Notation (BPMN) (Object Management Group (OMG), 2011). The only time notion present in an e^3value model is that such a model shows the value transfers for a specific time period, the contractual period. Multiple actors of the same type (e.g. customers) can be represented as a *market segment*, representing that a constellation e.g. has many customers rather than just one.

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The *e³value* method is a quantitative approach. Monetary values can be attached to value transfers, occurrence rates can be attached to needs, and dependency paths can contain splits or merges with pre-determined fractions.

A core concept of *e³value* is the principle or reciprocity which says that in a transaction, something should always be provided in return for a value transfer. In other words, value transfers in one direction should always be accompanied by at least one value transfer in the opposite direction. Formally, this means that for an *e³value* model to be valid all economic transactions should contain at least two transfers, one in each direction and that either all the transfers in a transaction occur, or none at all.

e³fraud

The *e³value* method assumes all actors behave as represented in the model. In other words: *e³value* models assume an ideal world, in that they represent a value constellation with actors that only behave as assumed by the model. The reason for this assumption is that *e³value* is first and foremost intended for business development; during workshops with stakeholders, it is already sufficiently difficult to understand which actors are involved, and what they exchange of economic value with each other, without having to consider actors who behave dishonestly. Because of this, we call *e³value* models *ideal* value models.

An extension to *e³value*, called *e³control*, is able to model scenarios in which not all business actors are to be trusted (Kartseva, Gordijn, & Tan, 2005), resulting in *sub-ideal* value models. The reciprocity constraint is dropped in order to represent that one or more value transfers do not occur (e.g. customer not paying for a product) or occur incorrectly (e.g. paying an insufficient amount of money) (Kartseva, Gordijn, & Yao-Hua, 2009). However, this is insufficient to model more complex types of fraud, such as the revenue sharing fraud in

telecommunication services (Ionita, Wieringa, Wolos, & Pieters, 2015). In our fraud analysis, we want to consider these more complex types of fraud too.

The *e³fraud* approach (Ionita, Wieringa, Wolos, & Pieters, 2015) is another *e³value* extension which allows for the construction of value models where actors violate agreements, contracts, or the law; the so-called *non-ideal* value models. In *e³fraud*, the focus is on how violations affect the expected revenues of other actors in the network, and extends the *e³value* ontology with the concept of *collusion, non-occurring* value transfers and *hidden* transfers. A collusion consists of two actors that act as if they were financially independent but which are in fact pooling their budgets, revenues and costs. A non-occurring value transfer is a transfer of value objects that in the *e³value* model is expected to occur, but does not. A hidden transfer is a transfer of value objects which are unexpected or otherwise hidden from the rest of the value network. The latter two are represented as dotted and dashed lines, respectively (see last two columns of FIGURE 1), while collusion is represented as a container surrounding each colluding actor. The bottom-left of FIGURE 3 shows a non-ideal variation of the model in FIGURE 2 containing all the three elements described above: Users A and B are colluding, the "Subscription fee" is not paid and there is a hidden payment from Provider B to User B for every call he receives. This is the so-called shared revenue scheme in which user B is paid when he receives a call (e.g. on an 0900 number) and shares this revenue with user A, who places as many calls as possible to B, without paying for it.

Since e3fraud is already implemented as open-source code, and because it supports a larger variety of heuristics, we integrate it into our proposed risk analysis method and tool.

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Deriving a Value Model from a Process Model

There are fundamental differences between the e^3value approach and business process modelling approaches (Gordijn, Akkermans, & Vliet, 2000). Specifically, they represent different, but overlapping information. This is because they take different viewpoints of the same value constellation. A business process model contains detailed information about sequence, iteration, choice, and parallel composition of activities, and specifies how the actors in a business network coordinate their work. By contrast, e^3value and e^3fraud models contain just enough information to make quantitative profitability estimations over a period of time. In e^3value and e^3fraud models, the concept of dependency path contains information on what commercial transactions are performed in a contract period to satisfy a consumer need, without describing which activities need to be performed and in which order so as to realize these transactions. The core concept in value modeling is *economic reciprocity*; the core concept in process modeling is *control flow*.

When designing a new e-service, stakeholders may start with developing the value model in order to arrive at a shared understanding about what they are able to offer to each other in terms of economic value before considering how these value propositions can be implemented in terms of business processes. However, if the businesses are already cooperating, stakeholders may want to re-evaluate the business value of this collaboration, or wish to re-engineer the operational business process. For example, because the business process or coordination process was developed or has evolved without consideration of the underlying value model and therefore the cooperation might not be (as) profitable, might contain redundant activities or might be vulnerable to fraud.

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To address this issue, Ionita et al (Ionita, Gordijn, Yesuf, & Wieringa, 2016) have proposed a semi-formal, semi-automated approach for deriving a value model from an existing coordination process model. A byproduct of this derivation is a mapping of activities to value creation and exchange, which we exploit in the case studies described below in order to extend our quantitative analysis to operational aspects of e-service provision in order to check if all activities make commercial sense.

RESEARCH METHODOLOGY

This research uses a combination of observational field studies, expert opinion, technical action research and case-based experiments and to develop, refine and evaluate a toolset of value-driven risk and sensitivity analysis methods.

In an observational field study, the researcher gathers information about the problem context and solution requirements in the real world. Observational field studies are gaining ground in the fields of accounting and information systems (Power & Gendron, 2015; Cooper & Morgan, 2008), and have proven useful especially during product development in order to elicit requirements (Courage & Baxter, 2004; Wixon, et al., 2002). They are usually conducted via observation and interviewing. In our research, we talked to several employees of a major German telecom's fraud department in order to obtain (1) information with regard to their current workflow in order to inform our solution design, and (2) case studies which we can use to validate the solution. Case 1 (Fraud assessment of a telecom service) is based on one of these case studies.

Expert opinion is one of the simplest ways to validate an artifact and involves submitting the design of the artifact to a panel of experts and ask them to imagine how the artifact would behave in the problem context (Wieringa, 2014). Expert opinion is therefore especially useful

during development (Rosqvist, Koskela, & Harju, 2003). In our research, we used expert opinion

to iteratively develop the generation and ranking heuristics used to generate fraud scenarios.

Specifically, we worked together with a major German telecom, as well as researchers looking

into telecom fraud in order to test the usability and utility of the supporting software tool (*e³tool*).

Technical action research involves using a newly designed artifact in a real-world context

in order to solve a real problem. To this end, technical action research is performed in the field. It

investigates the behavior of the artifact in the intended context, but – unlike other validation

methods - also attempts to help the client (Wieringa, 2014). In our research, we used technical

action research in order to validate the sensitivity analysis method described in the next section.

Case 2 (Sensitivity assessment of a copyright clearing service) is based on the results obtained

from performing technical action research at a Dutch copyright clearing organization.

A case-based experiment is a validation method by which the researcher applies stimuli

to an artifact in a simulation of the intended problem context, and observes its responses in an

attempt to draw conclusions with regard to the inner workings of the object of study (Wieringa,

2014). Case-based experiments are typically simulations in which a prototype of the artifact is

embedded in a simulated problem context and exposed to an experimental treatment, in order to

observe and understand the operation of the artifact (Wieringa, 2014). Case 3 (Sustainability

assessment of a food ordering and delivery process) is an instance of a case-based experiment

performed in the laboratory.

RISK AND SENSITIVITY ANALYSES

In this section, we present the analysis techniques promised in the introduction, starting

with an extension of the original *e³value* static estimation of net value flow from *e³value* models

to e^3fraud models, and then continuing with sensitivity analysis and fraud analysis of business models, and sustainability analysis of coordination process models.

Static Analysis of Ideal and Sub-Ideal Value Models

The original e^3value analysis is an analytical net value flow calculation, which generates a profit sheet for each actor and each activity (Akkermans & Gordijn, 2001). This sheet describes the financials of each actors across the contractual period specified in the value model. The e^3fraud extension also supports net value flow calculation, with the added benefit of also being able to compute the difference in financial results between the non-ideal (fraudulent) and the ideal (honest) case. This difference could be negative for some actors – signaling a loss, or positive – signaling a gain. Fraud typically leads to loss for a business actor, and financial gains for the fraudster. A higher loss means a higher impact for the business actor when the fraud is attempted, while a higher gain could motivate more potential fraudsters to attempt it (Ionita, Wieringa, Wolos, & Pieters, 2015). We suggest using losses as indicators of impact and gains as indicators of likelihood, thereby allowing analysts to compute a quantitative estimation of the risk.

Sensitivity Analysis of Ideal and Sub-Ideal Value Models

While our analysis does provide a quantitative estimation of the potential profitability of a value constellation (if ran on an ideal model) or of the potential losses caused by a misbehavior (if ran on a non-ideal model), no indication is given with regard to the error margins of these estimations. The authors recommend analyzing what-if scenarios in order to understand the sensitivity of the value model to changes in parameters, but with the tool support described so far, this has to be performed manually. That is, the model or its quantification has to be changed and the profit sheets have to be re-generated, and then finally compared with the original sheets.

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This method is time-consuming, unstructured, and does not give any information with regard to trends or the scalability of the service.

In order to streamline the sensitivity analysis of value models, we present in the case studies below an automated, chart-driven approach. Using e^3tool, for any e^3value or e^3fraud model, the user can execute sensitivity analyses which produce a chart showing the evolution of each net value flow with regard to either the number of times a selected need is triggered per contractual period or with regard to the size of a selected market segment. The user can choose the range to be displayed, and can zoom in on parts of the chart or export it for reporting.

To generate the chart, fifty copies of the selected e^3value or e^3fraud model are instantiated. In each one, the selected parameter takes equally distributed values across the selected range. Each model is then analyzed and the results are plotted on a chart. The color of each line in the chart is determined by the respective actor's name so that cross-comparisons are easier.

These charts have multiple uses. First, they act as streamlined sensitivity analyses of e^3value models. Second, when ran on e^3fraud models, they can show how a particular fraud scenario scales up and how the profitability of the service is affected by the (relative) number of fraudsters. Third, they can be used to compare e^3value models to related e^3fraud models and to compare e^3fraud models to each other. This, in turn, can be used to compare variations of a service with regard to its profitability, to highlight the impact of fraud, to compare different fraud scenarios or to obtain an estimate of the Return on Investment of fraud mitigation mechanisms.

Automated Generation & Ranking of Sub-Ideal Value Models

For any given e-service and its corresponding e^3value model, there are many possible frauds, each with its own corresponding e^3fraud model. While e^3tool supports the manual

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construction of e^3fraud models as well as adding fraud elements to existing e^3value models, doing this one fraud scenario at a time is time-consuming and may miss relevant scenarios.

Previously, Ionita et al. (Ionita, Wieringa, & Gordijn, 2016) presented a method to automatically generate e^3fraud models from any given e^3value model. The approach works by applying combinations of known fraud heuristics to the model and sorting the resulting models based on their effects. The fraud heuristics are:

- Collusion of two actors, who act as if they were financially independent but which are in fact pooling their budgets, revenues and costs;

- Non-occurrence of value transfer that in the e^3value model is expected to occur;

- Hidden transfer of value objects that are unexpected or otherwise hidden from the rest of the value network.

The approach always takes the perspective of a single actor, called the Target of Assessment. Of course, this actor can be chosen and changed. Sorting can therefore be performed either based on the estimated loss for the Target of Assessment, on the estimated gain of any other actor, or a combination of both. In addition to implementing this approach, e^3tool provides the ability to select multiple trusted actors and to choose which fraud heuristics be applied. Furthermore, it supports tweaking the heuristics described in the original approach: users can choose to allow collusion of more than two actors, can select which types of value transfers may not occur and can define how the valuation of hidden transfers is to be calculated. Finally, to mitigate search space explosion, e^3tool groups models with similar financial results and provides several filtering option such as hiding e^3tool models which are neither profitable for the would-be fraudsters nor cause any loss for the Target(s) of assessment. Each generated model comes with a graphical preview, as well as with a table comparing its financial results to those of

the original model used as input. Sensitivity analyses can be ran on the generated models from within the fraud generation module, but models can also be opened in the editor, where they can be further modified or saved.

Identifying Potential Sustainability Issues in Coordination Process Models

The *e³value* ontology prescribes a strict formalism for constructing value models. For instance, all value transfers should be reciprocated and be part of a pre-defined value transaction. This is because *e³value* models are designed to show that a business network is profitable under ideal conditions. In *e³fraud*, many of these requirements are relaxed. Therefore, it is possible to arrive at an invalid *e³value* model. This can happen either because the modeler made a mistake, or because of flaws in the design of the e-service.

To support the quick identification of modelling mistakes but more importantly, the identification of design errors which could threaten the profitability of the service, *e³tool* comes with a built-in model checker. It visually highlights elements which go against the guidelines of *e³value* but also allows the user to ignore some non-critical issues and run profitability analyses in order to assess their impact. This supports the identification of potential issues related to the financial sustainability of the service but be applied to existing services too.

Furthermore, by leveraging research into relating value models and process models (Pijpers & Gordijn, 2008), deriving process models from value models (Wieringa, Pijpers, Bodenstaff, & Gordijn, 2008; Hotie & Gordin, 2017) and the other way around (Ionita, Gordijn, Yesuf, & Wieringa, 2016), it is possible to obtain in a partly automated way, for a given service, a value model, a coordination process model and a mapping between the two. The value model can then be checked and any errors traced back to the coordination model, thereby providing an understanding of both the cause of the issue and its potential impact on profitability.

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To sum up, we have described the following techniques to construct and analyze value models:

1. Static analysis of ideal and sub-ideal value models. Compute profit resulting from participating in a value constellation as a bona fide actor or as a fraudster.

2. Sensitivity analysis of ideal and sub-ideal value models. Shows how profit changes with number of occurrences of consumer need per contractual period, or with the size of a market segment.

3. Generation and ranking of sub-ideal value models from ideal value models. In an ideal value model, select a subset of actors as trusted, generate all possible frauds possibly committed by untrusted actors, and rank fraud models on loss for a trusted actor(s) or gain for untrusted actor(s).

4. Assess business sustainability coordination process models. Match a coordination models with a value model and assess mutual consistency.

CASE STUDIES

In order to demonstrate the utility of the analysis techniques described in the previous section, we show how they were applied to three case studies. All of the three studies are about using value models to mitigate profitability risks, but to illustrate generalizability of the approach, each case study comes from a different domain, and has different requirements:

1. A study from mobile telecom where we are interested in generating and ranking fraud scenarios for a given telecom service (Case 1);

2. A study from copyright clearing where we are interested in quantifying the evolution of a risk based on several parameters (Case 2);

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3. A study from food delivery where we are interested in streamlining the order handling process from an economical perspective (Case 3).

Case 1 was obtained by performing interviews with stakeholders of a major German telecom provider. In Case 1, we already knew the solution and wanted to verify whether our methodology can arrive at the same result faster. Case 2 was an instance of technical action research. In Case 2, we were presented with a problem, and we used the e3fraud methodology to solve it. Case 3 is based on a well-known BPMN practice case. In Case 3, we wanted to investigate whether the value-driven coordination model risk analysis method can be applied to arbitrary process models.

All three case studies concern e-services provided by a network of collaborating entities. In the telecom case, there are a multitude of providers, each with large numbers of subscribers. In the copyright case, the rights clearing house has to deal with both consumers and producers of copyrighted content. In the food delivery case, we only show the restaurant and the customer in order to keep the example understandable.

Case 1: Fraud Assessment of a Telecom Service

Telecommunication services, especially mobile ones, are e-services par excellence: delivery, billing, and often even contracting are mediated by information technology. In addition, operating in a dynamic and highly competitive market forces telecom providers to constantly re-engineer, re-design, re-package or re-market their service offerings, while focusing their risk management efforts on fraud detection rather than fraud prevention.

Indeed, interviews with stakeholders of a major German telecom confirmed a need for quick, re-usable fraud assessment tools which can provide actionable insight on the types of frauds possible before or during the deployment of a new service offering. To this end,

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quantitative projections of the scalability of the fraud provide an indication of both its potential impact and its attractiveness, which can be used to derive thresholds after which consumers can be flagged or even cut off (Ionita, Wieringa, Wolos, & Pieters, 2015). In addition, we learned that graphical representations of the relevant fraud scenarios promote a better understanding and clearer communication of the fraud scenarios identified to decision-makers than traditional spread-sheet based approaches. Research show that graphical model facilitate location of vulnerabilities and constructive reasoning about possible mitigations (Gordijn & Akkermans, 2001). Finally, because of the large search space, the process should be automated where possible (Ionita, Wieringa, & Gordijn, 2016). In what follows, we build an ideal value model, generate sub-ideal fraud models, and do a sensitivity analysis of the sub-ideal models.

Step 1: Build (or Adapt) Value Model

The first step in performing a value-driven risk assessment is obtaining a value model of the target of assessment. In this case study, we explore the fraud possibilities provided by flat-rate mobile telephony contracts. Flat-rate contracts allow the customer to perform an unlimited number of calls to selected numbers or networks and are well known for being targets of fraudsters, especially as part of Revenue Share Fraud schemes (i3 Forum, 2012). We constructed a value model for a flat-rate telecom plan and instantiated it with real prices, as offered by a major Dutch telecom provider in 2016. This model is shown in FIGURE 2.

Step 2: Identify Potential Fraud Scenarios

Once the value model of the service is available, we need to identify, analyze and compare the types of fraud possible, in order to identify potential sources of profitability risk. *e3tool* provides two ways of exploring fraud scenarios: automated generation and manual construction.

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2(a) Manually build and analyze sub-ideal value model

For known fraud scenarios, the tool allows the creation of *e3fraud* models from scratch, or from an existing *e³value* model. Profitability and sensitivity analyses can be executed on these manually constructed fraud models and the results compared to the ideal *e³value* model. This allows users to quantify the impact that individual fraud scenarios have on the profitability of the service for all actors involved, as well as the potential gain afforded to would-be fraudsters.

2(b) Automatically generate and rank sub-ideal value models

Even for the rather simple value model of FIGURE 2 and only considering the three fraud heuristics defined by the *e³fraud* ontology – that is, collusion, non-occurrence and hidden transfers - can still result in a combinatorial explosion of potential fraud models. Many of these scenarios may either cause no (significant) loss or provide no potential gain. To facilitate the exploration of this search space, we can make use of the automated fraud scenario generation module.

Loading the flat-rate value model of FIGURE 2 into the fraud module, and selecting only the Provider as a trusted actor, we obtain a total of 19 fraud scenarios which result both in a reduction in the revenue of the trusted actor, and in an increase in the revenue of one or more of the other actors, when compared to the original value model. FIGURE 3 shows a screenshot of this list, ranked by loss for the Provider. For each scenario, when selected, the bottom-right of the screen shows the financial result for each actor in the network as a result of the fraud as well as comparing it to the financial result had the service been delivered as expected. In addition, the user can run a sensitivity analysis on these results in order to obtain an indication of how the fraud (and its impact) may scale with regard to usage or market size. The bottom-left of the screen shows a visual representation of the fraud scenario using the *e³fraud* language. When

clicked, this preview is opened in the editor so that it can be further customized, analyzed or tweaked.

Step 3: Mitigate Fraud Risk

The results above allow the analyst to quickly identify the costliest and most likely frauds. In addition, it provides information on the existing transactions which would need to be bypassed or the new transactions which would need to be introduced in order to make the fraud possible. Based on this, a risk mitigation decision has to be made. Typically, this means to either (1) accept the risk, (2) attempt to reduce its likelihood or impact, (3) eliminate the risk or (4) transfer it. For services, this translates into either providing the service as it is, re-engineering the service, discontinuing it, or imposing fair-use policies. One other option, common for metered services, is to set-up fraud detection systems which monitor usage and flag consumers which act suspiciously.

The results of the analysis can help the analyst make these decisions, as well as to operationalize them. For instance, the projected losses can help decide whether or not to accept the risk. If the magnitude of the risk exceeds risk acceptance criteria, the results of sensitivity analyses can help identify thresholds for fraud detection systems or fair use policies. Finally, after re-engineering the service and updating the value model accordingly, the assessment can be re-ran in order to check the effectiveness of the change.

Conclusions of Case 1

The quantitative analyses provided by e3tool provide actionable knowledge which can be fed into the re-engineering process, can form the basis for fair-use policies or can inform fraud detection thresholds. For instance, in our example, a sensitivity analysis might reveal that certain types of fraud only become profitable (or damaging) after a certain amount of calls per month.

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This number could then be used either as a detection threshold, or as an upper bound of the fair use policy.

In addition, the results themselves could be used to quickly produce feasibility reports on the profitability risks related to a specific service which are both detailed enough to support cost-/benefit analysis, and high-level enough to be relevant for decision makers.

Case 2: Risk Assessment of a Copyright Clearing Service

Rights clearing is the procedure by which an organization acts as an intermediary between copyright holders - such as artists, producers or record labels - and consumers, broadcasters or distributers of copyrighted content - such as radio stations, movie theaters or restaurants -. Clearing is required in order to make sure each copyright holder received his fair share of earnings. Therefore, rights clearing organizations are commonly non-profit entities owned and ran by artist syndicates and perform three core tasks: (1) maintain an up-to-date–database of copyrighted content and its owners, (2) gather information with regard to the usage of said content, and (3) collect copyright fees and distribute them to their respective owners.

Each of these activities involve risks. Artists might try to unfairly claim copyright on works they did not contribute to, Broadcasters might not declare usage of copyrighted content accurately or completely. And since most copyrighted work, such as music and film, is a product of several collaborating entities, copyright owners might mis- or over-represent their role in the creation process. All of these risks ultimately affect the income of content producers so it is in the best interest of any copyright clearing organization is to minimize them.

Luckily, market research firms can provide statistics with regard to most types of broadcasting which can be used to verify usage reports. However, validating copyright claims is much harder since the only individuals with knowledge about the creative process that led to the

creation of a copyrighted work are the performers themselves. But it is infeasible to, for every

claim, contact all of the other entities known to have contributed to the work. Therefore, a trade-

off has to be achieved between minimizing the risk of accepting an invalid claim and the

annoyance generated by the validation process.

Since the risk of false positives in the claim handling process can be described in terms of

value shifts (some performers might gain undeserved earning, while others might see their share

reduced), this case lends itself well to value modelling. Specifically, we propose using sensitivity

analysis to quantify the risk associated with each new claim. This, in turn, can be used to derive

validation requirements for each claim. We start with building a value model of the copyright

clearing service.

Step 1: Build (or Adapt) Value Model

To begin, we need a value model which describes how income from the recording to

which the claim pertains is being distributed. Fortunately, this allocation is determined based on

some pre-established criteria so it is possible to create a general model can be adapted per

recording.

The value model in FIGURE 4 represents how a Dutch copyright clearing organization

handles the distribution of income from the usage of copyrighted recordings. Producers always

receive half of the value, while the remainder is distributed among the performers, depending on

their role: artists receive five shares, conductors receive three shares and the others receive only

one share. Therefore, the stake each contributor is entitled to depends on the value obtained as a

result of usage, his role, as well as on the number of other contributors of each type. Once the

model is instantiated with concrete values, we can compute the financial result of each individual

actor at the click of a button using e3tool's profitability table.

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Step 2: Run Sensitivity Analysis

Next, we want to identify the financial impact of accepting the claim under question. Of course, one option would be tweak the values in the model accordingly and re-run the profitability analysis. But this will return absolute values, whereas the risk is better understood in terms of relative loss, i.e. how much of the share does one stand to lose. In addition, this kind of analysis provides only a snapshot of the risk and no indication on its evolution.

We therefore prefer to use the sensitivity analysis functionality, as it can generate charts showing how the profit of each producer and type of performer changes with the addition (or removal) of copyright claims of producers or performers. For instance, if we select "COUNT of studio musicians or orchestra members" as a parameter, we obtain a chart such as the one in FIGURE 5. The chart describes the relationship between the number of claims of a specific type (in this case, claims of studio musicians or orchestra members) and the financial entitlements of current copyright holders.

Step 3: Elicit Claim Validation Criteria

The sensitivity chart of FIGURE 5 shows the impact of one or more new copyright claims by studio musician(s) or orchestra member(s) on the revenue of the current copyright holders. Therefore, it is useful for the elicitation of validation requirements for new claims of studio musicians or orchestra members. Similar charts can be generated for any type of claim, on any copyrighted work by tweaking the value of the work and/or choosing different sensitivity analysis parameters. A steeper slope means that particular actor would be more affected if the claim is validated. As the curve flattens out, the impact - and therefore the marginal risk - is reduced. Therefore, the validation criteria required at each particular point should be proportional to the steepness of the curve at that point. In addition, relative steepness (compared to the curves

of other entitled entities) is an indicator of disproportionate risk for entities fulfilling that role. This should require a larger number of those entities be involved in the claim's validation.

Conclusions of Case 2

Sensitivity charts show how profitability depends on factors such as market size and usage frequency. But, when applied to sub-ideal models, sensitivity charts can also be used to show

(1) how the impact of a specific risk is correlated with factors such as market size and usage and

(2) how the gains from exploiting a specific risk is correlated with factors such as market size and usage.

The former is useful for deriving risk acceptance criteria and, if need be, risk mitigation policies. The latter is useful for obtaining an indication with regard to the incentives other actors in the value constellation might have to mis-behave. Together, they can be used to quantify risk, as well as to understand how this quantification is correlated with factors regarding market size and usage.

Case 3: Sustainability Assessment of a Food Ordering and Delivery Process

This case study is focused on demonstrating how value models can be used to rationalize and improve business processes. Specifically, we look at how we can identify sustainability threats to the service provision process. To this end, we take as an example the well-known process of food delivery to the home. The case study is heavily based on the pizza delivery coordination process incorporated by SAP and the Object Management Group in their business process modelling training materials (SAP Inc., 2013; Object Management Group, Inc., 2010) In

what follows, we start from a coordination process model, map this to a value model, and then identify sustainability threats in the coordination model using the value model.

Step 1: Derive Value Model from Coordination Model

FIGURE 6 shows the coordination process model of the order handling process using the BPMN formalism. By applying the derivation technique described in (Ionita, Gordijn, Yesuf, & Wieringa, 2016) and summarized in the previous section to this coordination process model, we obtain the respective value model of the order handling process depicted in FIGURE 7. TABLE 1 summarizes the decisions made in terms of mapping BPMN activities and flows to e^3value value transfers.

Step 2: Identify Potential Sustainability Threats

Using the resulting value model of FIGURE 7 and the mapping of TABLE 1, we can now rationalize the service delivery process in terms of value. We can therefore reason about its profitability and also use the techniques illustrated in previous sub-sections to identify potential profitability risks. However, in this section we focus on the special kinds of analyses afforded by relating the value perspective to the process perspective.

2(a) Manually identify superfluous activities

Some activities present in the process model might not correspond to any value exchanges in the process model. This can happen for several reasons. The activity may not transfer any value from an actor to another, or it may provide value for other actors not present in the model. In addition, it may provide (delayed) value to the actor performing it, for example by serving as a logging or archiving mechanism.

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Looking at TABLE 1, we see that the "Notify cook" activity was not mapped to any value exchange. This is an indication that the activity is superfluous from an economic perspective and a decision should be made as to whether or not the activity is really needed.

2(b) Automatically identify non-reciprocal transfers

The e^3value formalism does not allow non-reciprocal value transfers. This is because business models seldom contain altruistic activities. Therefore, any model which contains such transfers is considered to be either incomplete or incorrect. e3tool provides a model checker which can highlight such issues automatically.

In our example, the value model (FIGURE 7) obtained from the service delivery coordination process model (FIGURE 6) has several non-reciprocal transfers, those of the "Order", of the "Request to cook" and of the "Cooked food". The last two transfers are internal, and therefore do not expect anything in return. However, the customer does not receive anything in exchange for placing the order. While this does not automatically imply there is something wrong (it could be that the reciprocal activity was simply out of scope for the process model), it could likely indicate that either the process model is incomplete or that the process itself is lacking from a value perspective.

Step 3: Improve Coordination Model

If the process model is found to be incomplete, it may be updated accordingly. However, if the process itself contains non-reciprocated transfers of value, then the value of the service itself can be improved by providing something in return.

In our example, the customer should receive something in return for placing the order. This could be a loyalty bonus, or simply a confirmation of receipt or an estimated delivery time.

Conclusions of Case 3

Value models, when used in concert with process models can provide a deeper understanding with regard to

(1) how value transfers are realized and

(2) what is the economic value of activities.

This in turn provides valuable information for (re-)engineering more robust and financially sustainable e-service provision processes. In particular, as demonstrated by this case study, it can help identify and correct common risk factors in coordination process models: superfluous and non-reciprocal activities.

CONCLUSIONS AND FUTURE WORK

Value models provide an established way of modelling the co-creation of value by independent profit-loss responsible entities. But co-creating value may bring about new vulnerabilities stemming from the potentially falsifiable assumptions that have to be made about the behavior of third-parties and even customers. The authors believe that existing value-driven analyses can be extended to help understand the effects of such vulnerabilities. As shown in this paper, value models can serve as a useful tool not only for estimating the profitability of a (new) e-business idea but – with the proposed extensions – they can also be used for quantitative risk and sensitivity analysis.

In their recent review of value models, Weigand and Jeewanie propose strengthening their connection with management research (Weigand & Jeewanie, 2009) so as to leverage their systemic perspective on how to do business (Zott, Amit, & Massa, 2011), with a focus on value creation, delivery and capture (Lambert, 2010). Our conceptual and methodological addition to e^3value moves it in the direction of a decision support tool, and this constitutes a strengthening of

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the systematic perspective on how to do business. We highlight in particular the fact that partial automation of the value model-driven risk assessment process can speed up the analysis process, while visualizations such as charts and graphs enrich the analysis by improving understandability of its results. Being model-driven also means our techniques facilitate re-use, as well as being constructionist in nature. Finally, the analyses we are able to perform using e^3fraud far exceeds what $e^3control$ lends itself to, both in terms of breath and in terms of strength. First because e^3fraud supports more, configurable heuristics, and second because of tool-support.

The proposed approach is extensible. Future work might reveal fraud heuristics other than the three identified in this paper (collusion, non-occurrence and hidden transactions), which can be added to the conceptual meta-model used by the automated fraud generation engine. Model patterns may be developed and used as templates, thereby increasing the usability and efficiency of the approach. Finally, integration with enterprise systems can feed values into the value models, ensuring up-to-date valuations as well as reducing the amount of error prone manual work.

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FIGURE 1 The e3value ontology (first 6 columns) and the e3fraud extension (last column)

Legend	Actor	Value interface	Value port	Value Transfer	AND element	OR element	Hidden transfer
	Market segment	Activity	Consumer need	Connect. element	Boundary element	Value object [...]	Non-occuring transfer
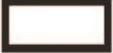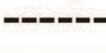
FIGURE 2 Flat-rate telecom service – value model
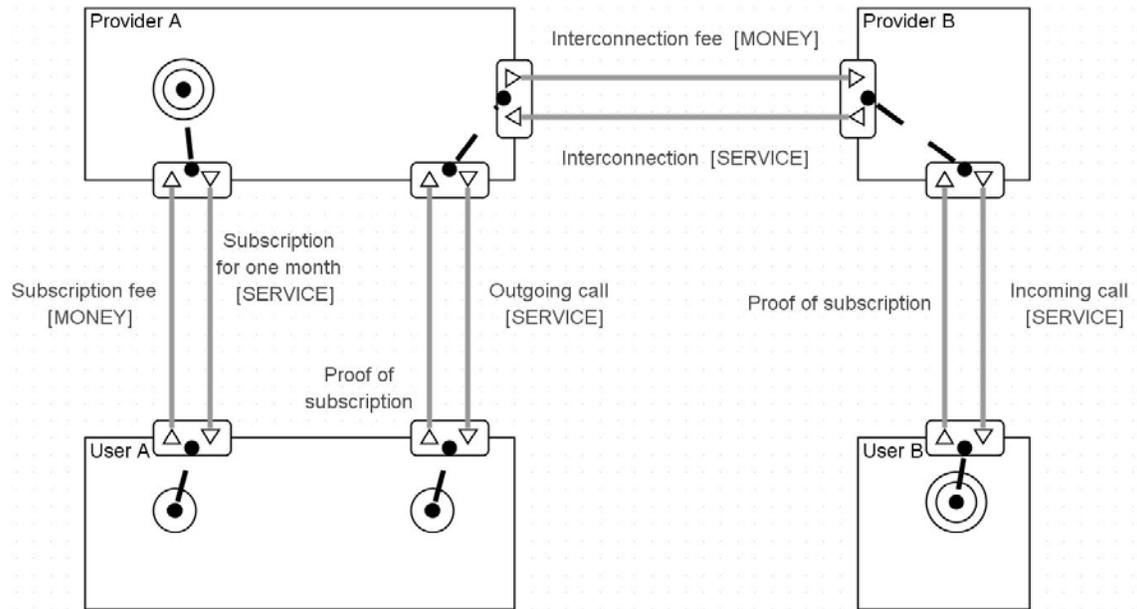
FIGURE 3 Screenshot of generated fraud scenarios based on the flat rate telecom service

FIGURE 4 Distribution of income resulting from the usage of a copyrighted recording – value model

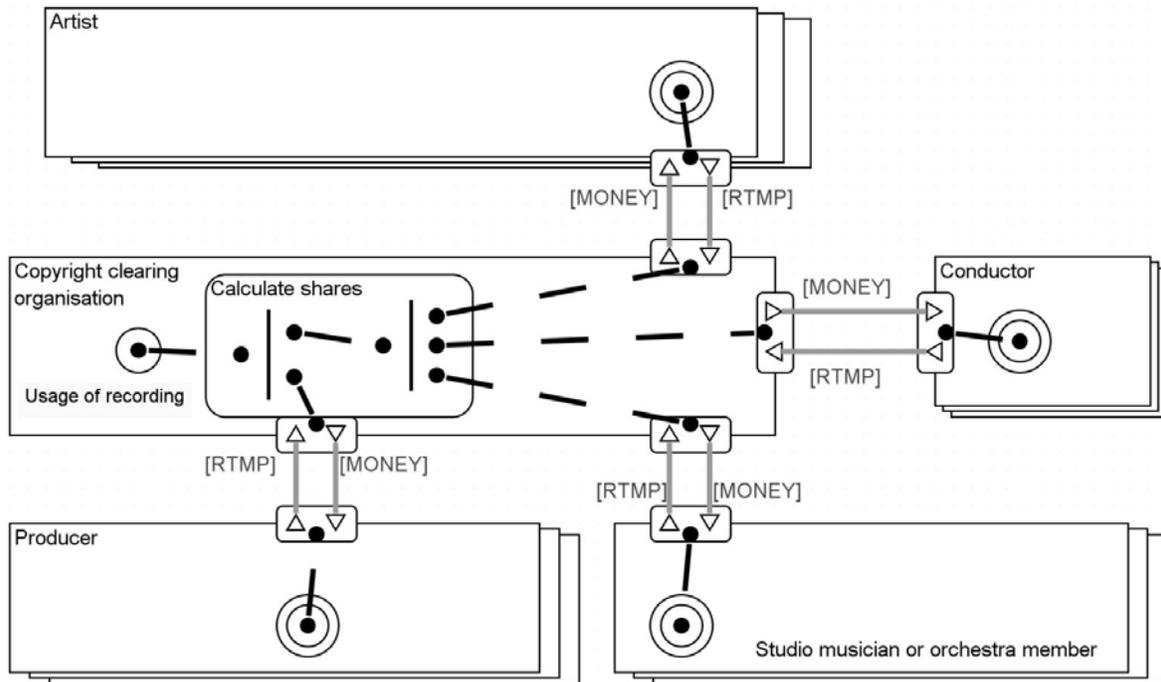**FIGURE 5 Sensitivity analysis showing the relationship between copyright revenue per role and the number of studio musicians or orchestra members**
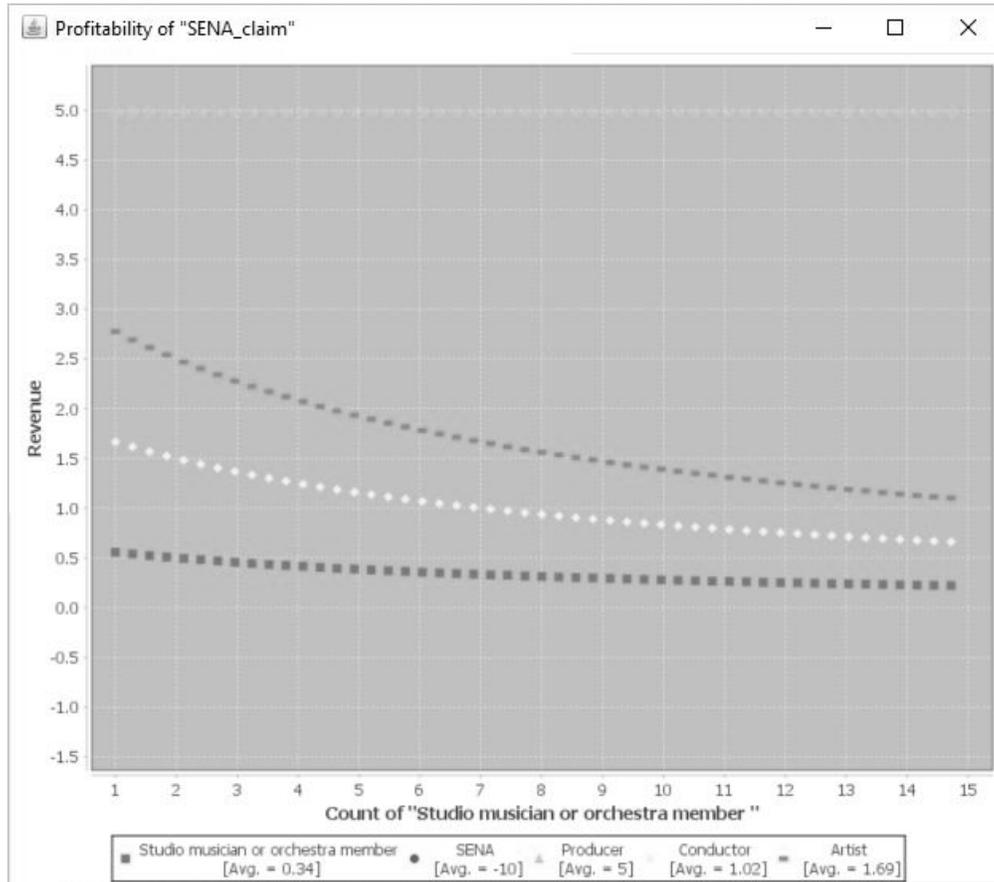
FIGURE 6 Order handling - coordination process model

TABLE 1 Order handling - mapping of activities and flows to value transfers

Activity or Flow	Corresponding Value Transfer
"select food" activity	
"order food" activity	
"order" message flow	Order
"Complain" activity	Complaint
"Calm customer" activity	Re-assurance
"Cook food" activity	Request to cook
"Cook food" -> "Deliver food" flow	Cooked food
"Notify cook"	NA
"Deliver food" activity	
"food" message flow	Food
"Pay for food" activity	
"Money" message flow	
"Receive payment" activity	Payment
"Receipt" message flow	Receipt

FIGURE 7 Order handling - value model