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Endurability and Profitability analysis of Collaborative Networks

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Abstract

A collaborative network is a network consisting of a variety of autonomous actors (e.g. enterprises, organizations and people) that collaborate to better achieve common or compatible goals. A collaborative network starts with a contract and then the collaboration partners conduct business as described in the contract. Before engaging in such a collaboration, partners need to reach an agreement regarding their responsibilities in the collaboration and develop a shared understanding regarding the endurability and the profitability of the collaboration. Here in this paper, we aim at analysing the endurability of collaborative networks based on the trust relations between collaboration partners and also introducing a new approach to do profitability analysis for collaborative networks. Therefore, we enrich the value models of business collaborations with information about trust, endurability and profitability.

Keywords: Collaborative Networks , Endurability, Profitability, Trust

1 Introduction

Nowadays, the networks that enterprises operate in become increasingly complicated. There are many reasons for this. Among others we can refer to more complicated user needs, upward tendency toward specialization, changing customer demands, higher customer satisfaction indexes, advancement in information and communication technology (ICT), globalization of markets and manufacturing, gaining competitive advantages, being exposed to a bigger audience, etc. In fact, collaboration of different enterprises to co-produce a product or service is nothing new however, here in this paper, we focus only on those business collaborations which are facilitated by ICT. In

other words, we are concerned with the design and use of IT in IT-enabled business collaborations.

A collaborative network is a network consisting of a set of autonomous actors (e.g. enterprises, organizations and people) that collaborate to achieve common or compatible goals [Camarinha-Matos and Afsarmanesh 2004, Camarinha-Matos and Afsarmanesh 2008]. Collaborative networks come with different names in the literature, such as business webs [Tapscott et al. 2000], Virtual enterprise (VE) [Katzy and Schuh 1997, Nayak et al. 2001], extended enterprise [Browne and Zhang 1999, Mostert 2004], strategic alliances [Rigsbee 2000, Mowery et al. 1996], value constellations [Normann and Ramírez 1993, Normann and Ramírez 1994, Gordijn and Akkermans 2002], to name a few. Tapscott et al. define a business web as a collection of enterprises designed to jointly satisfy a consumer need [Tapscott et al. 2000]. Katzy and Schuh define virtual enterprise as a temporary co-operation to realize the value of a short-term business opportunity that none of the partners can capture on its own [Katzy and Schuh 1997]. The virtual enterprise manifests a dynamic environment where individual enterprises work together for a relatively short time, to satisfy niche market demand quickly whereas the concept of the extended enterprise focuses on long-term enterprise relationships across the value chain. The extended enterprise is responsible for the whole product life cycle and it includes the relationships that an enterprise has with its customers, suppliers, business partners, even former competitors and so on [Browne and Zhang 1999]. A strategic alliance is a cooperation or collaboration that aims for a synergy where each partner hopes that the benefits from the alliance will be greater than those from individual efforts. The alliance often involves technology transfer (access to knowledge and expertise), economic specialization, shared expenses and shared risk [Mowery et al. 1996]. Normann and Ramirez [Normann and Ramírez 1993, Normann and Ramírez 1994] introduce the value constellation as a successor of the value chain [Porter 1996]. A value constellation is a construct where actors come together to co-produce value with each other.

As it can be seen, the collaboration of some enterprises to co-produce a product/service is the common theme of all the above definitions. Nevertheless, this collaboration can have different forms based on the degree of commitment and the level of engagement of the partner members. For example those enterprises that provide complementary products or services in a touristic area can make a collaborative relationship in which many local tourism providers, collaborate in order to market a particular location as a fun tourism destination. This would involve hospitality service providers like hotels, B&Bs, guesthouses, and self-catering owners working closely with providers of activity based interests (horse riding, water sports, biking, hiking, historical places of interest, fishing, quad biking etc.) to create a compelling holiday destination tourism value proposition for a specific area. This type of collaboration can be created by publishing some joint brochures, recommending each other's services to existing and potential customers, creating a hyperlink on each other's website, etc.. Due to the complementary nature of their products and services, these companies would be more successful and have more profitability if they collaborate. At the same time, they can still do their own business outside the collaboration and if one partner fails in delivering the promised service/product it does not necessarily terminate the collaboration.

In contrast, there are business collaborations in which each partner contributes with its own specific products or services to achieve a common goal that cannot be achieved

when one of the actors drops out of the collaboration. Therefore the collaboration of all partners is necessary to achieve the common goal of the collaboration. If one of the partners fails in delivering his/her undertakings and responsibilities then no other partner can achieve its goal(s) and consequently the collaboration fails. For example, a web shop, a logistics company, a payment provider and an authentication provider can jointly provide the on-line shopping service to consumers. In this collaboration if one of the partners for example the logistic company fails in delivering its undertakings the collaboration fails. This type of collaboration manifests a joint work which we call collaborative network and here in this paper we address this kind of collaboration.

We use business value models to model collaborative networks. A business value model helps the collaboration partners to share their understanding regarding the collaboration and enables them to analyse economic profitability of the collaborative network. The main goal of business value modelling is to reach agreement amongst profit-and-loss responsible actors regarding the question "Who is offering what of value to whom and expects what of value in return?" We use the e³value method to describe/represent collaborative networks from value point of view [Gordijn and Akkermans 2002]. E³value is supported by a tool that allows profitability analysis for all partners in the network.

In the current state of the art, the collaboration partners are assumed to be trustworthy while designing value models. However, in real life, all partners are not equally trustworthy and therefore, before a business value model can be put into operation, any unrealistic trust assumptions that it contains, must be removed. The contribution of the paper is to enrich business value models with trust and then analyse the impact and implication of trust on the endurability and profitability of collaborative networks.

In section 2, we discuss the endurability of collaborative networks using existing trust relations between partners. Then in section 3 we introduce a new approach to refine the current profitability analysis by taking into account the cost which is associated with the realization of every value exchange. This allows us to compare risk (working with untrustworthy partners) with profitability. Together, this allows us to define criteria that business actors can use when deciding to join collaborative networks. Later in section 4, we apply our findings on a case study and finally we conclude in section 5.

2 Endurability of Collaborative Networks

Endurability of a collaborative network is a major property of the collaborative network that enables it to continue to function despite undesirable events. For actors participating in a collaborative network it is vital to have an indication of how durable is the collaboration. Each business collaboration is meant to be operating for a specific period (contract period) and therefore collaboration partners need to know if the collaboration is strong enough to last throughout this contract period. To analyse the vulnerability of collaborative networks, we consider two main aspects 1) structural stability 2) execution durability. Structural stability stems from the relations between the partners in the collaboration while execution durability arises from the way in which partners collaborate with each other.

For structural stability analysis of a collaborative network we use the initial trust relations between actors and for execution durability we exploit the profitability analysis of collaborative networks. We will see that the more initial trust relations there

are between the actors and the more profitable collaboration there are the less vulnerable the collaborative network is, and consequently the more durable would be the collaboration.

2.1 Structural Stability of Collaborative Networks

We use the trust relations between the actors to determine how stable a collaborative network is. To do that, we assume that we are comparing two or more overlapping collaborative networks. Then we first design a model which we call the *general trust model*, which represents all actors in all possible collaborative networks and the trust relations between them. The general trust model is a directed graph in which a directed edge/arrow from actor A to actor B means that actor A trusts actor B to collaborate with it in a business collaborative network. In other words, the trustor accepts the risks of collaboration with the trustee. Trust is always with regard to a specific activity and here it is with regard to the responsibilities and agreements made in the contract. When an actor trusts another actor it means that the trustor trusts the trustee to act according to the agreements made in the contract/value model.

We also design a simple model which we call *value exchange model* for each collaborative network. The value exchange model is a simplified version of a value model of e^3 value. The value exchange model is an undirected graph in which nodes represent the actors participating in the collaborative network and an edge between two actors means that those two actors are going to be in direct relation with each other in the collaborative network i.e. they exchange value objects with each other in the value model and therefore there should be a trust relation between those two actors. We will use the trust model to analyse static endurability and the value exchange model to analyse execution stability of collaborative networks.

After designing the general trust model and the value exchange model of each collaborative network, we classify the collaborative networks in three groups by superimposing the value exchange model associated with each collaborative network on the general trust model as follows:

- **Stable:** If there is a mutual trust relation in the general trust model between every two actors that are connected in the value exchange model, then we conclude that the corresponding collaborative network of the value exchange model is structurally *stable*.
- **Weakly Stable:** If there is at least one trust relation in the general trust model between every two actors that are connected in the value exchange model and at least one of the trust relations is not mutual, then we conclude that the corresponding collaborative network of the value exchange model is structurally *weakly stable*.
- **Not Stable:** If there is no trust relation in the general trust model between a pair of actors that are connected in the value exchange model, then we conclude that the corresponding collaborative network of the value exchange model is structurally *not stable*.

Those collaborative networks which fall in the last group (Not Stable) are left out of consideration, since they are not feasible and not realizable because as Kenneth J. Arrow [Arrow 1973, page 24] pointed out " . . . ethical elements enter in some measure

into every contract; without them no market could function. There is an element of trust in every transaction". Those collaborative networks which fall in the first group (Stable) are better (more enduring) than those that are in the second group (Weakly Stable). In general, the more mutual trust relations between the actors the better because more coordination patterns can be deployed and the realization of the collaboration manifests more flexibilities.

The trust model is dynamic and it can undergo some changes during the course of the collaboration. These changes can be because of the appearance of a new trust relation or disappearance of an existing one or even the increase or decrease in the trust value of existing trust relations. These changes may imply certain collaboration patterns and therefore actors need to adapt their actions accordingly.

Figure 1 demonstrates a collaboration between two actors, A and B, in which actor B provides A with a service for a fee (see Figure 1(a)). Assume that at the outset of the collaboration, only A trusts B and B doesn't trust A (see Figure 1(b)). Theretofore actor B agrees to collaborate with actor A only if A pays B before receiving the service each time (see Figure 1(c)).

Now, assume that after some time, B grows trust in A and therefore a new trust relation is added to the trust model (see Figure 2(b)). This might change the process because B might drop the payment condition so that A can pay B after receiving the service. This means that A can pay either after or before or even partly after and partly before receiving the service. This new situation is demonstrated in Figure 2. Note that in the coordination pattern shown in Figure 2(e) both actors need to trust each other at some point in time during the collaboration because actor A first pays 20% of the fee before receiving the service and then actor B provides A with the service before receiving the fee of the service completely. These percentages can also change due to the changes in the level of trust that each actor has in the other actor.

Hence, changes in the trust model can implicate some changes in the way that actors collaborate with each other. In an extreme case, two actors which are in direct relation with each other in the collaboration, might end up in a situation in which none of them trusts the other anymore and therefore the collaboration terminates. That's the time to go back to the drawing board and design a whole new collaborative network from the scratch.

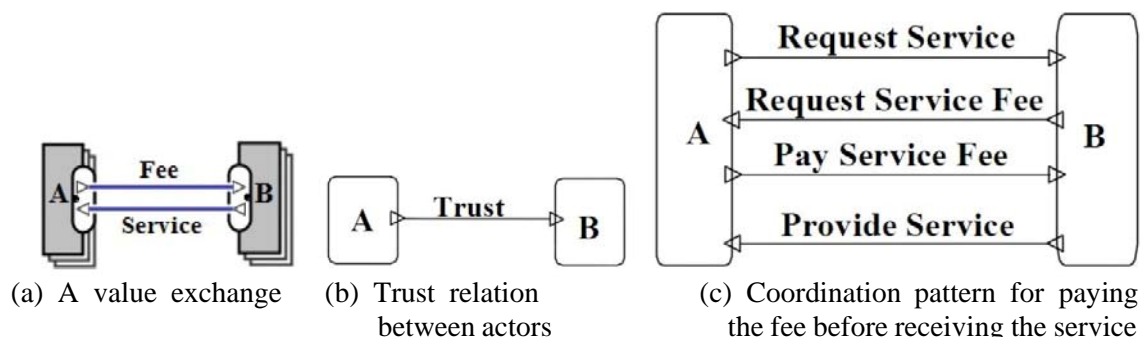


Figure 1: A coordination pattern of a value exchange

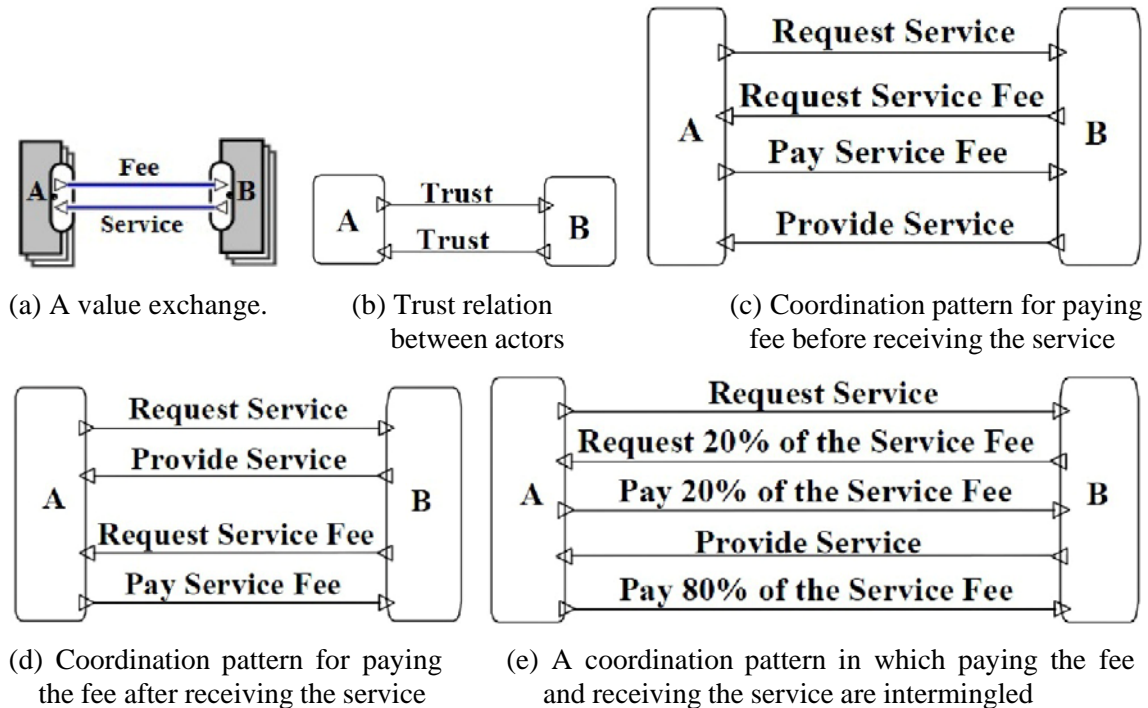


Figure 2: Possible coordination patterns of a value exchange

2.2 Execution Durability of Collaborative Networks

Having enough initial trust relations between the collaboration partners, we can implement the business case and put it in action. For how long the collaboration goes on, depends on many factors. To name a few: what is the initial trust situation?, how sensitive the stakeholders are? (do they break the collaboration after noticing that the other partner do not fully respect the promises?), how profitable the collaboration is?, etc. After all, the collaboration is meant to be during a specific period (contract period), so we can rephrase the initial question as: Does the collaboration last throughout the contract period?

The only way to know if the collaboration can last throughout the contract period is to wait until the contract period is over. Nevertheless there are some indications which can be used in the reasoning process. To do that we need to predict the way in which partners will collaborate with each other. If they fulfil their responsibilities in full or at least to a great extent and if the collaboration is predicted to be profitable enough for all partners, then we can expect that the collaboration will last throughout the contract period. If a partner does not act according to its promises then the continuation of the collaboration depends on the quality of his collaboration performance and also on the sensitivity of its partners.

A collaboration partner might neglect some of the flaws of its partner or degrade its estimated trust value in the wrong doer partner slightly, while another partner might degrade its estimated trust value severely or even break the collaboration in reaction to the same flaw. The sensitivity of a collaboration partner in breaking a collaboration depends highly on the profitability of the collaboration. In some cases, a collaboration might be still profitable/motivating enough for an actor even if its partner does not act

fully according to the agreements and therefore that actor will still continue with the collaboration though probably with more precautions and preventive measures.

Because of the above reasons it is hard to predict how long the collaboration will last, nevertheless structural stability and equitable profit distribution among the group (i.e. each collaboration partner earns enough profit) are two main criteria which can be considered.

3 Profitability Analysis of Collaborative Networks

The e³value tool which we use to model collaborative networks, consists of a graphical part and a computational part. The graphical tool is a diagram editor and the computational tool is a spread sheet editor with algorithms that can perform Net Present Value (NPV) estimations for the actors in the diagram. To do the profitability analysis of a collaborative network, each partner needs to assign values in terms of money to each value object which it gives and receives. That basically means how much each object is worth for each actor. In this way, each actor can measure how much value/money it gets per value exchange provided that the exchange takes place as described in the value model. Then by estimating the number of value exchanges during the contract period we can tell each actor how much profit it is going to earn out of the collaboration. There are some assumptions in this approach and to better understand the mechanism we need to explain some of these assumptions.

- Assigning monetary values to all exchanged objects is not always straightforward. If someone is paying 10 € to watch a movie we generally can assume that watching the movie is worth more than 10 € to that person. However assigning a specific value to the movie depends on many factors among others the personal taste of the person regarding that particular movie. In general, not every object of the same type delivered by an actor necessarily has the same value for another actor, and that makes assigning a fixed monetary value to objects not always straightforward. In addition, from the producer's point of view, actors need to assign monetary value to those objects which they deliver as a function of the cost of producing that object. This too is not always straightforward.
- Estimating the number of expected exchanges during the contract period is another challenging issue.
- The value model describes an ideal situation in which all actors fulfil their responsibilities and act according to the agreements (i.e. actors are assumed to be trustworthy). To have a more realistic estimation of the profitability of a collaborative network we need to drop this assumption and take into account those factors that can affect the profitability of a collaborative network. It is not easy, if not impossible, to identify all possible risks and the probability and impact associated with each value exchange.

Dropping each of these assumptions introduce some cost. Here in this paper we only discuss the third assumption. Dropping the third assumption would mean monitoring partners' behaviours and inspecting value objects, which impose some cost. In the current state of the art of profitability analysis which are done based on the value model, this cost is not taken into account. To make the profitability analysis results more

realistic and reliable we suggest to assign a cost which we call *risk cost* to each value exchange and then adjust the results accordingly.

The amount of surveillance and monitoring which an actor would like to have on the behavior of another actor in the collaboration, depends on the level of trust between those two actors. Therefore, to estimate the risk cost we first need to quantify the trust relations between the partners. In our previous work [Fatemi et al. 2011] we proposed a method for measuring and managing the trust values between the collaboration partners in a collaborative network.

Now, consider the value exchange shown in Figure 3, which simply means actor A gives value object V_a to actor B and in return actor B gives value object V_b to actor A and assume that actors A and B assign the monetary values to value objects V_a and V_b as shown in Table 1. This implies that value object V_a costs 10 € for actor A and it is worth 11 € for actor B and likewise value object V_b costs 8 € for actor B and it is worth 12 € for actor A. This means that stakeholder A earns 2 € (12 € - 10 €) in each transaction and stakeholder B earns 3 € (11 € - 8 €), provided that the exchange takes place as described in the value model and the realization of the value exchange doesn't impose any extra cost.

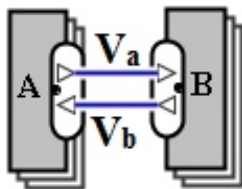


Figure 3: A value exchange between two stakeholders

	V_a	V_b
A	10 €	12 €
B	11 €	8 €

Table 1: Monetary values of V_a and V_b according to actors A and B

Assuming that in a [0-1] scale, the trust value of A in B is 0.85 and the trust value of B in A is 0.90. This numbers can be interpreted in two ways: 1) Currently A is 85% certain that B will deliver value object V_b according to the agreements and analogously B is 90% certain that A will deliver value object V_a according to the agreements. 2) A believes that, in the long run, 85% of the times B will deliver value object V_b according to the agreements and similarly B believes that, in the long run, 90% of the times A will deliver value object V_a according to the agreements.

Base on the above reasoning, the real profit which A can expect in this collaboration is $(0.85 * 2 \text{ €}) - (0.15 * 10 \text{ €}) = 0.2 \text{ €}$, because 85% of the times the exchange goes well while 15% of the times actor B does not fulfil the agreements (in the worst case actor B does not send actor A anything back) and therefore actor A loses its value object (V_a) totally. Similarly, the real profit which B should expect is $(0.9 * 3 \text{ €}) - (0.10 * 8 \text{ €}) = 1.9 \text{ €}$.

As another case assume that A does not trust B and only B trusts A and the trust value of B in A is 0.8. This, first of all, means that only certain coordination patterns are applicable and also it means that A does not take any risk in this collaboration (i.e. actor A always receives value object V_b first and then sends B value object V_a if he is satisfied with the exchange). Therefore the expected profit of A out of each exchange is 2 € (12 € - 10 €) and the expected profit of B is $(0.8 * 3 \text{ €}) - (0.20 * 8 \text{ €}) = 0.8 \text{ €}$.

In this way all partners should calculate the refined profits and then decide for engaging in the collaboration only if the refined profitability estimations are still acceptable. Using our method for managing trust [Fatemi et al. 2011], actors can do this calculations at any point in time during the collaboration and make their decision for continuing the collaboration based on the result of the calculations.

There are special kinds of value exchanges which we call *not observable* and in those cases the profitability analysis is even more complicated. For example assume that a pub undertakes to pay an Intellectual Property Right (IPR) organization a special amount of money for playing each track of music for being able to play the music. Assume also that the IPR organization does not have any specific control on the pub, i.e. the IPR organization does not know which tracks the pub play. In this particular case, IPR organization either trusts pub and assumes that pub will always pay for all the tracks or it needs to do inspections to verify the trustworthiness of the pub. This inspection costs money and it should be taken into account in the profitability analysis. We have used game theory concepts to analyse the profitability in these special transactions in which an actor collaborates with another actor in the hope that he would act reciprocally [Fatemi et al. 2012]. The trusting actor runs an inspection, which costs money, every now and then to know if the other actor acts according to the agreements or not. Solving the game provides the involved actors with the *risk cost* and consequently they can adjust their profits accordingly.

What happens in reality is that an actor decides to engage in a collaboration with another actor which might be unknown to it. In that case, it means that the actor starts with full trust and therefore it accepts the risk of collaboration with an unknown actor which implies that the trusting actor might lose the value object it delivers completely without receiving anything in return. However our proposed method [Fatemi et al. 2011] to manage the trust relations and the method presented here can be used later in the collaboration.

4 An Illustrative Case Study

We have applied the analysis presented in Sections 2 and 3 on an illustrative case study about educational services. The idea is that people are looking for specific jobs that require special skills. Since the required skills for a person (customer) cannot always be provided by a single educational service, it is needed to find meaningful combinations of services that can jointly provide a valuable solution to the customer, i.e. a service value network (SVN).

To test our solution framework, we have harvested the publicly available National Database of Accredited Qualifications (NDAQ), which contains details of Recognized Awarding Organizations and Regulated Qualifications in England, Wales and Northern Ireland that offer different skills through educational services. The final service catalogue is composed of 58 services provided by four service suppliers.

Figures 4 and 5 depict two possible SVNs that have been composed to cover the need: "As a multimedia creator, How can I improve my skills?". As it can be observed in Figure 4, the SVN provides a solution to this need by networking several services. At the top, a service bundle offers the required skills FC_1 (Digital Image Manipulation), FC_2 (Photo Image Capture) and FC_3 (Studio Photography) by combining three

educational services. At the bottom, three service enablers support the functioning of the service suppliers.

In this manner the problem at hand is twofold: 1) It is required to provide a set of solutions when a customer needs to acquire some skills. 2) Once the alternative solutions are offered to the customer, it is important to provide a selection criterion so that the customer can choose one option among the set of alternatives.

To deal with the first issue, one of us has previously presented a framework that (semi)automatically composes alternative SVNs to cope with customer needs [Razo-Zapata et al. 2011]. Briefly, whereas a customer expresses his/her need in terms of the required functionalities (the skills in this context), and then a cluster-based algorithm composes alternative SVNs that can satisfy the given customer need, i.e. alternative networks of educational services [Razo-Zapata et al. 2011].

In order to solve the second issue, we propose the analysis described in Sections 2 and 3 to evaluate the endurance and profitability of a given SVN. Consequently, the customer is provided with information that allows him/her to choose one SVN not only matching his/her need in terms of required skills but also in terms of economic profitability. The

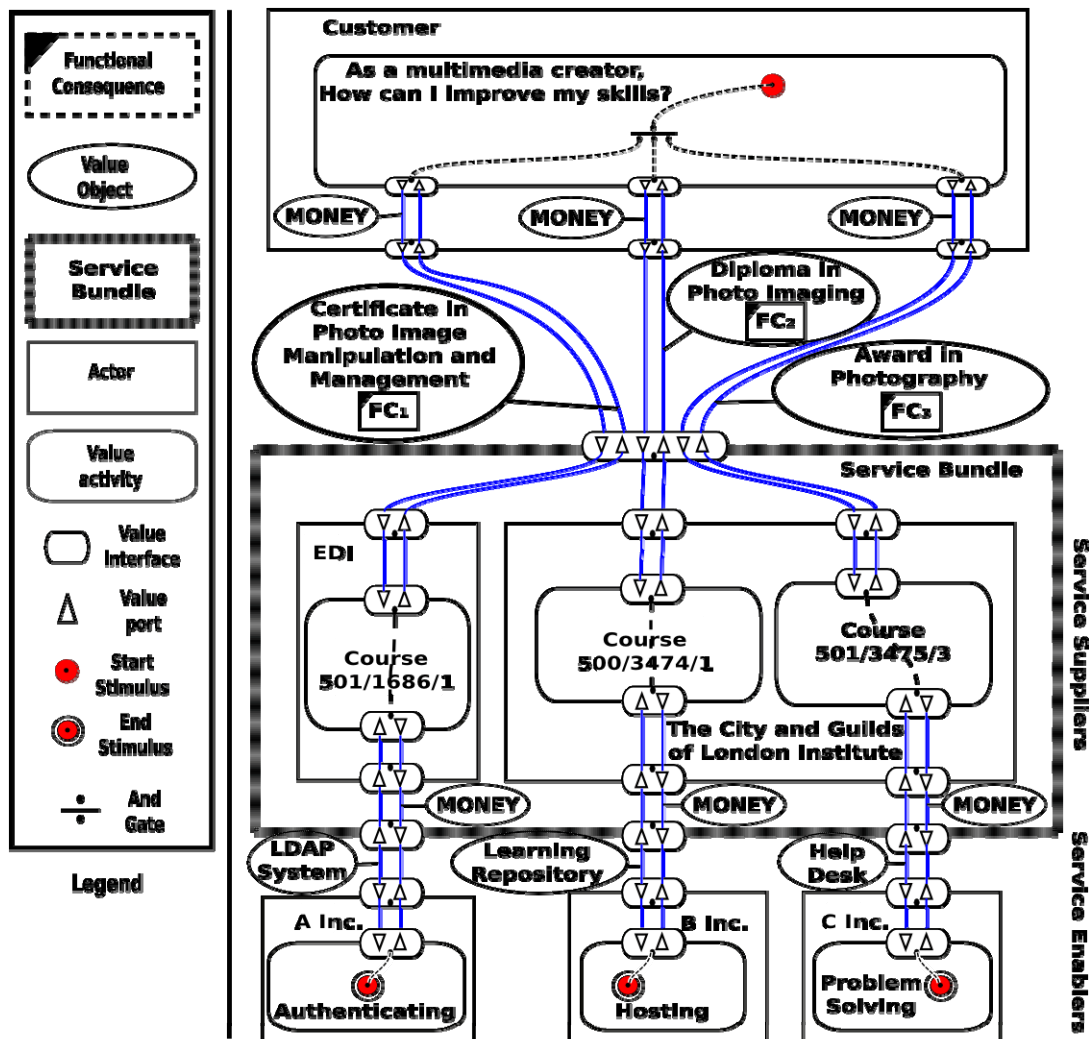


Figure 4: A service value network

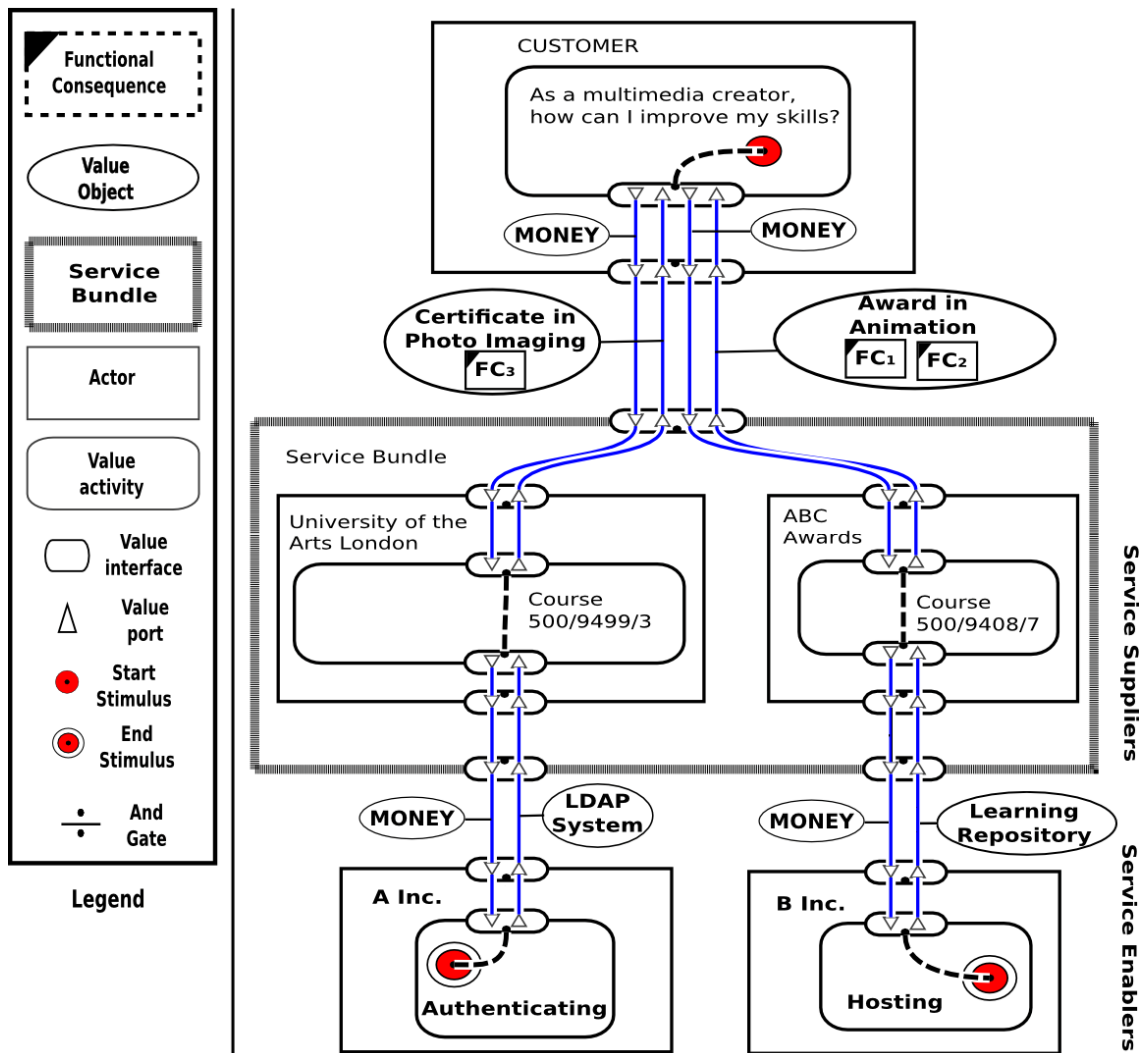


Figure 5: A service value network

trust relations and their quantified values are shown in the general trust model (See Figure 6). The value exchange model of the two collaborative networks are shown in Figures 7. In this models CGLI and UAL stand for 'the City and Guilds of London Institute' and 'University of the Arts London' respectively.

After superimposing the value exchange models on the general trust model it turns out that the collaborative network shown in Figure 4 is *Not Stable*, and the collaborative network shown in Figure 5 is *Weakly Stable*. Therefore we exclude the collaborative network shown in Figure 4 and continue the profitability analysis with the collaborative network shown in Figure 5.

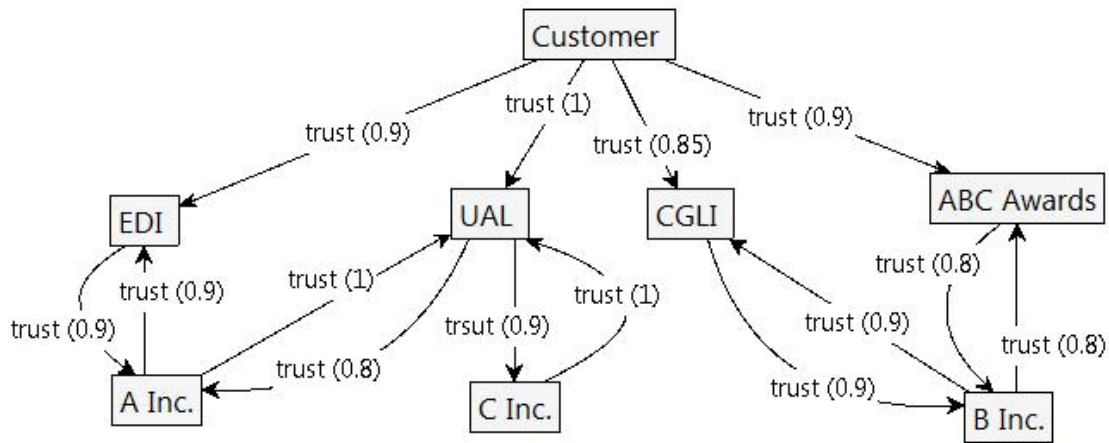


Figure 6: General trust model



(a): Value exchange model of collaborative network in Figure 4

(b): Value exchange model of collaborative network in Figure 5

Figure 6: Value exchange models of collaborative networks

	Money	Certificate ...
Customer	1000 €	1200 €
UAL	1000 €	700 €

Table 2: Monetary values of value objects exchanged between the Customer and UAL

To do the profitability analysis, the participating actors should assign monetary values to each value object they exchange. Table 2 shows the monetary values of a pair of value objects in the collaborative network shown in Figure 5. For the sake of brevity, here we only explain the value exchange between the Customer and the UAL (see Table 2). As it can be seen in the general trust model, the UAL does not trust the Customer so it does not take any risk in this collaboration therefore, it earns 300 € in this collaboration. However, the trust value of the Customer in the UAL is 0.95 therefore, the expected profit of the Customer is $(0.95 * 200 \text{ €}) - (0.05 * 1000 \text{ €}) = 140 \text{ €}$.

In this case, we can interpret the results as follows: The UAL provides the Customer with a service/course and because the Customer is unknown to the UAL, it does not trust him/her therefore the UAL does not take any risks and it charges the Customer

1000€ upon registering for the course. On the other hand, based on the reputation of the UAL and/or the Customer's investigation, the Customer believes that with probability of 95% the UAL provides the service/course as he/she expects.

5 Conclusion and Future Work

In this paper we analysed the collaborative networks from endurability and profitability points of view based on the trust relations between the collaboration partners. Providing the partners with value models supplemented by extra information regarding the endurability and profitability of the collaboration, enables them to decide on those collaborations which are more durable and profitable. Since value models depict the required exchanges to achieve a business goal, when they are enriched with information about trust, endurability and profitability, they can provide more insights to specify service level agreements among the participants within the network.

Taking appropriate detective and preventive measures in value exchange process can affect the level of trust which collaboration actors have in each other. For example an actor that does not trust another actor might trust him if the collaboration is secured with appropriate safeguards. As future work we aim at enriching our analysis with safeguards and measures.

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