Founding Trust in an eBusiness Environment

An explorative study

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Version History

Version	Changes
0.10	- Updates in theory chapter - Some improvements on argumentation - Introduced theory on markets and foundations - Restructuring of last chapters - Declared Validation and Verification chapter - Case Introduction moved to introduction chapter
0.11	- Updates in theory chapter - Included application to B2B domain - Introduced the design process (section 4.2), the core of this report.
0.12	- Updates in theory chapter - Completely rewritten section 2.2.2 - Some updates in chapter 4 - Rewritten thesis outline
0.13	- Introduced more TCE in chapter 2 to build theory used in chapter 4 - 4-layer model - Uncertainty, asset specificity etc. - Working on rewriting chapter 3 - Including better requirements - Better coupling to chapter 2
0.14	- Restructuring report: Split first chapter - Start with existing theory in chapter 2 - Build 'new' theory in chapter 3 - Requirements moved to chapter 3 from 4 - First sketch of decision model on paper.
0.15	- Abandoned version.
0.16 – 0.22	- Major rewrite. - Sections abandoned - New sections introduced - Changed storyline
Beta 1	- Included last chapters - Version were all information is included
Beta 2	- Removed Validation and Conclusion chapters.
Beta 3	- Reintroduced Validation and Conclusion chapters.
RC1	- Minor adjustments throughout the report.
RC2	- Storyline changes: - Changed research goal and research questions correspondently.

	- Changed storyline to wrap around Williamson's 4-layer model - Decision model has been removed. - Updated other texts accordingly - Minor textual changes throughout the report

Final	- Applied changes proposed by Jan v.d. Berg where deemed possible and desirable.
	
	   - Replaced working title
	
	   - Changed research goal and research question
	
	   - Structure changed in chapter 2; 2.4 included in 2.1
	
	   - Moved 5.1 into chapter 3.
	
	   - Changed naming of solutions in ch.4 to reflect previous findings
	
	   - Added Preface and Reflection
	
	   - Many small adjustments to the content
	
	   - Added a recommendation

Contents

1 Introduction

1.1 Motivation

Our world is one of continuous change. New markets are spawning and in existing markets product lifecycles get shorter and shorter. Several strategies are followed to keep up with the accelerated development of the market. A common strategy is to return to the 'core competencies' and outsource or sell other parts of the company. Another common strategy is to cooperate with other companies in innovation. A good example thereof is the Senseo coffee machine, which was developed in cooperation between Philips and Douwe Egberts.

The same movement towards cooperation can be seen online, where webservices and concepts like Software as a Service (SaaS) are gaining momentum. The online environment is however significantly different from the classical offline market. In an offline environment two business partners can get to know each other and learn about each other through different kind of interactions. By building a relationship two transaction partners learn to trust each other before they go into the transaction. In an online environment there is little room for building a relationship. Transaction decisions are not based on direct interaction, but on information available online. As trust is an important part of every transaction, systems are needed to support the building of trust in an online environment.

1.2 Research Problem

There are various technological solutions which are termed "trust management" systems (Blaze, Feigenbaum, & Lacy, 1996; Chu, Feigenbaum, LaMacchia, Resnick, & Straus, 1997) or which are aimed on providing reputation systems in a digital environment (Resnick, Zeckhauser, Friedman, & Kuwabara, 2000). Far more has been written on these topics, but they share a common shortcoming. There is only a partial understanding of the concept of trust. Information systems are a supporting tool for businesses and their transactions. Therefore the design of information systems should be based on the needs of those businesses. A thorough understanding of the need for trust in business transactions is needed, such that trust management or reputation systems can be built, in order to fulfil these needs.

The research in this report is aimed towards those who want to implement a system to support trust in an online environment. It can be a certification authority (e.g. VeriSign), who wants to expand their current business. Or a partner in a value chain, who needs to make regular choices between suppliers and wants to use trust as a factor. Or a trade organisation, who wants to enhance the way their members do their business. The common denominator is that these parties recognise a certain transaction in which trust can be a deciding factor when choosing between transaction partners.

These organisations could use set of guidelines, which they can use to design a trust system. They can use insight in the notion of trust and all of its characteristics, focussed on an eBusiness environment. It might be helpful for them to know where to start when designing a trust system. It would give them insight into the considerations that have to be made, how these considerations should be made and the effect of those considerations on the design.

The research also supplies new concepts and ideas to the academic community. Especially the use of economic theories to support the designing of a trust system has a lot of potential and this research provides the first steps in that direction.

1.3   Research Goal

Given the previously stated problem, the research goal is:

> *To develop a decision framework for founding trust in an eBusiness environment.*

It is good to clarify some of the terms in this research goal. A *decision framework* is here defined as a set of decisions to be made and a decision support tool.

The definition of *trust* will be discussed later in great detail, but for now it suffices to use the following definition: Trust is "a psychological state comprising the intention to accept vulnerability based upon positive expectation of the [..] behaviour of another" (Dirks & Ferrin, 2001, p. 451).

This also clarifies part of the *use of trust* in the research goal. If for there are multiple transaction partners for whom such an 'intention to accept vulnerability' exists, it is possible to make a decision between these partners based on the level of the intention, choosing the one who you trust most. So with 'using trust' in this case is defined as using trust as one of the deciding factors in the decision between multiple possible transaction partners.

The research goal has been narrowed down to an e-business-to-business environment. This is still very broad, as it comprises all transactions between two businesses. This can vary from simple transactions such as ordering staples from an office supplier to transactions using complex webservices or services like Salesforce.com or Google Apps. This demarcation has been made to exclude private transactions and thus narrow the research.

1.4   Research Questions

The following research questions are formulated in order to reach the research goal.

Main research question:

Which framework can be used to decide upon the foundation of trust to use in a given eBusiness environment?

Research sub-questions:

1. *How can trust be defined in an eBusiness environment?*

2. *Which different classifications of trust can be identified?*

3. *Which requirements can be derived from the definition and classification of trust?*

4. *What are the available IT-solutions for managing trust in e-business transactions given the definition and classification?*

5. *How can a choice be made between different types of trust and trust systems?*

1.5   Research plan

The research will start with defining trust (1), so it can be used to derive requirements (2). The next step will be to match existing IT-solutions to these requirements (3). The result of all this work is the basis of the framework design (4). This framework will be tested (5) using expert opinions, retrieved using interviews, questionnaires or workshops and augmented accordingly (6). At the end of the research a reflection will be done on the whole project and the derived results.
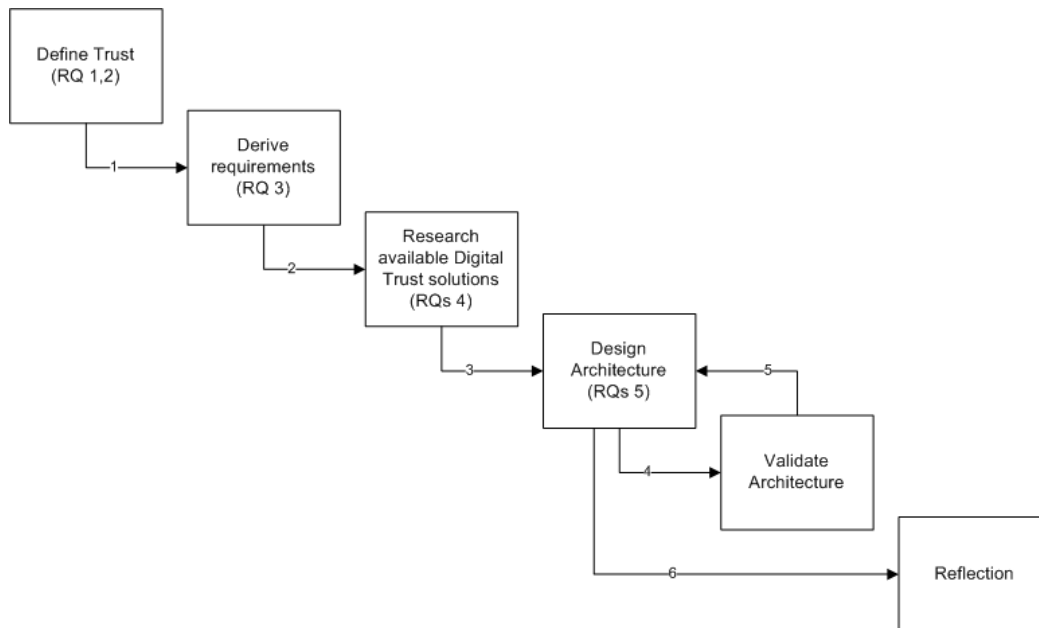
Figure 1: Research Model

1.6 Relevance

The research described in this report is relevant in several ways. First of all the result of the analysis of economical and sociological literature about trust is a necessity for further work on the development of digital trust models. Current work on digital trust models is done with a limited understanding of the concept of trust, often based on one or two sources in sociological literature. Implementation of these technological trust models is not as straightforward as it might seem. Next to the technology institutional constructs are needed to support the technology, which will be described in a later chapter. As a last point this research will point out new knowledge gaps, which have to be solved for a complete implementation of trust. It can therefore be used as a starting point for future research in the area of trust models.

1.7 eBusiness transactions

The starting point of this thesis is enabling the design of trust-aware systems for online business-to-business (B2B) transactions. As the name already suggests B2B transactions are transactions between two businesses. Those transactions exist in many types. One example is the purchasing of office supplies by a company from a supplier. Another example is the use of web services by a company from a web service provider.

The use of a trust-aware system is dependent on two factors: the transaction occurs in an online environment and is automated. In the example of the office supplies one could think of a system that monitors the stock levels of office supplies and automatically orders new supplies from the 'best' vendor when stocks are below a threshold. In the case of web services a trust-aware system becomes relevant in for example automated service discovery systems. These systems automatically choose the 'best' web service provider based on a set of requirements.

In both cases the last step in the trajectory, the actual choice of a provider, can still be done by an actual individual, but the general idea is that this individual is provided with a 'trust-rating', which reflects the trustworthiness of the provider.

1.8 Thesis Outline

This thesis will start with a discussion on the theories on trust found in sociological and economical literature. In chapter 3 these concepts and theories are operationalised and placed into the eBusiness environment. Chapter 4 describes existing trust solutions and how they fit to the operationalisation of chapter 3. Chapter 5 introduces a draft decision model which can be used during the design of a trust system in an eBusiness environment. In chapter 6 the research is partly validated, resulting in recommendations.

2 Existing Theories on Trust

The aim of this chapter is to define trust. What is it, what do you trust in, where does trust come from? This has been discussed regularly and many different ideas coexist. By analysing these different ideas a synthesis is made. This chapter starts out with discussing the definition of trust. It is followed by a analysis of what it is one trusts. Trust is part of a transaction which takes place in an environment. This idea is introduced here and will be elaborated on later on. The chapter finishes with an analysis of the foundations of trust found in literature.

2.1 Defining Trust

Trust is a difficult subject, and this is reflected in the fact that probably one of the most quoted statements about trust is Gambetta's 1988 statement that trust is an 'elusive notion' (Gambetta, 1988b, p. vii). Even though it is a familiar concept in ordinary life, many scholars seem to avoid the topic rather than approach it head on. As Luhmann states: "Trust has never been a topic of mainstream sociology." (Luhmann, 1988, p. 94). Also in economics trust seems to be banned to the outskirts, where less traditional economists try to understand the foundations and functions of trust. Nonetheless, in the last decade Trust has gained in popularity amongst scholars. Most scholars who do approach the topic of trust seem to agree that trust is an essential part of social and economic life (Bachmann, 2001; Clarke, Hardstone, Hartswood, Procter, & Rouncefield, 2006; Dirks & Ferrin, 2001; Fukuyama, 1995; Luhmann, 1988; Nooteboom, 2002, 2005; Ratnasingham, 2001; Woolthuis, Hillebrand, & Nooteboom, 2005; Zucker, 1986). In economical theories trust is seen as "the most efficient mechanism for governing transactions" (Zucker, 1986, p. 56), while in organisational theory scholars "seem to agree that trust is highly beneficial to the functioning of organisations" (Dirks & Ferrin, 2001, p. 450). Some sociologists even go as far as stating that without trust, society itself would disintegrate (Clarke et al., 2006).

So why is this topic often neglected by other scholars? Fukuyama argues that economics has been "dominated by neoclassical or free market economists" (Fukuyama, 1995, p. 13) and that neoclassical economics is preoccupied with the idea of "rational utility-maximizing individuals". Trust does not fit the profile of a rational actor. This line of reasoning follows Herbert Simons influential work on rationality. Simon says the following on rationality in neoclassical economy compared to psychology:

> *The rational person of neoclassical economics always reaches the decision that is objectively, or substantively, best in terms of the given utility function. The rational person of cognitive psychology goes about making his or her decisions in a way that is procedurally reasonable in the light of the available knowledge and means of computation.* (Simon, 1986, p. 211)

So due to its preoccupation with rationality, neoclassical economics does not tell much about trust and its functions. Trust is a more common concept in other fields of research, such as institutional economics, organisation theory and sociology. This work builds on those.

As discussed before, trust is an elusive notion. In the last decade, quite a few scholars have written about it and many different theories have come up. Let us start with a few basic notions about trust. Nooteboom (2005, p. 66) states: "Trust is taken here as a four-place predicate: the trustor (1) trusts a trustee (2) in one or more aspects of behaviour (3), under certain circumstances (4)"[1]. The

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[1] Trustor: The party placing trust in another party.

fourth point is important to understand. Trust is context-sensitive, meaning that trusting a trustee in a certain situation does not mean the same trustee is trusted in a different situation. A common view in such a case involves a certain amount of risk taken by the trustor (Bachmann, 2001; Camp, Nissenbaum, & McGrath, 2002; Clarke et al., 2006; Dirks & Ferrin, 2001; Hosmer, 1995; Luhmann, 1988; Nooteboom, 2002, 2005; Shapiro, 1987; Woolthuis et al., 2005; Zucker, 1986). When the trustor trusts the trustee, he knows that when the trust is abused he will lose. On the other side, the trusting behaviour also brings about advantages, which could not be gained without trust (Camp et al., 2002; Luhmann, 1988). Browsing through the different definitions of trust found in literature (see Appendix A), two different perceptions of trust arise. Some state that trust is an action (Camp et al., 2002), but a more common term for trust as an action is 'trusting behaviour'. Trust is more regularly referred to as an expectation or 'psychological state'. The definition by Rousseau as quoted by Dirks and Ferrin (2001) gives us a reference definition, which reflects most of the aspects of trust mentioned in literature. He defines trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectation of the [..] behaviour of another".
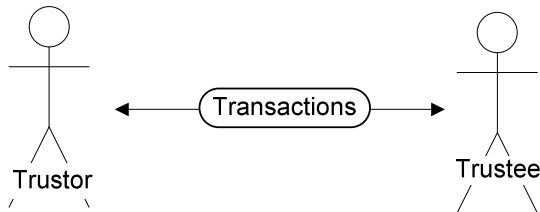
Figure 2: Basic transaction in an e-business environment

In the case of the above figure, this means that the trustor has a positive expectation of the behaviour of the trustee. If the trustor intents to transact with the trustee he is willing to accept some risk based on the level of that expectation.

Many scholars have written about the functions of trust. Commonly accepted is that trust enables economic activity. Some say it is the most efficient mechanism for governing transactions (Bachmann, 2001; Zucker, 1986). Others state that without trust "societies falter and collapse" (Hosmer, 1995, p. 379), or that it mitigates relational risk (Woolthuis et al., 2005). Again an overview of the functions of trust defined in literature is given in Appendix A.

It is generally accepted amongst these authors that trust is necessary for proper long-term cooperation. It is even essential for the formation of strategic alliances and other 'hybrid' forms of cooperation (Bachmann, 2001). Another common idea is that trust mitigates or reduces risk, or helps the trustor deal with uncertainty. A last function of trust that appears throughout the literature is the reduction of transaction costs. It does so by reducing costs for all stages contact, contract and control (Nooteboom, 2002).

According to the predicate, there is a trustee and there are aspects of the behaviour of the trustee. The trustee can be anything ranging from a person, organisation or institution to an object. However, one cannot just trust a person; one can trust certain aspects of a person. These aspects one can trust in are here called the "Forms of trust". First a literature study was done to reveal the forms of trust presented in current scientific literature. As a second step the different forms of trust were clustered in as few clusters as possible.

Trustee: The trusted party.

The results of this literature study are presented in Appendix A. Among other things, the appendix presents the forms of trust given in each article. The result of the clustering of these forms of trust is shown in the following table.

Intention	Competence	Predictability	Other
Intention	Competence	Predictability	Material
Benevolence	Ability	Predictability of actions	Conditional
Goodwill		Regularity	Exemplar
Honesty		Behaviour	Informational
Integrity			Passion
Ethicality			
Cooperativeness			
Reliability			

Table 1: Clustering of Forms of trust found in literature

In the first column there is a long list of forms, which say something about the intention of the trustee. Is the trustee good willing and honest in his dealings with the trustor? All the terms in this column can be grouped under the term 'intentional trust', which is also commonly used in literature. In the second column there are two commonly mentioned forms, which are essentially equal. Can the trustee actually perform the requested action, seen his competence? These forms of trust are equal and can thus be grouped under the term 'competence trust'. The third column shows a set of terms all concerning the behaviour of the trustee. The trustee would have predictable and regular behaviour, on which decisions can be based. The last column in the table shows the remainder of the forms of trust. The first four are all from the work of Nooteboom (2002), which he derived from Aristotle. Although they are certainly interesting, Nooteboom underwrites that it is hard to distinguish between these different types of trust (2002, p. 53) and he does not use them in later work (Nooteboom, 2005). Here we follow this argumentation and do not use his four additional types of trust. The last one in column four, 'Passion' is an outsider. It comes from Williamsons work on trust, in which he claims that trust is irrational and only occurs in personal relationships, like families, in which it is derived from passion. The view of Williamson on trust will be discussed later, but passion is not something one can trust in. This means all types in column four are discarded.

The three remaining clusters are *intention*, *competence* and *predictability*. On a first glance, predictability seems a bit out of place. Is predictability not a result of trust, rather than a form of trust? If the trustor has knowledge about the intentions and the competence of the trustee, he can predict the behaviour. Trust in predictability overlaps both trust in intention and trust in competence.

One example to clarify this is the following case about lending out a car. If we lend out our car, we trust that the trustee drives well and will not crash the car. We trust in his competence as a driver. Secondly we trust him to return the car to us and not to steal the car. We trust in the intention of the trustee. Including predictability of behaviour would not help in explaining the case.
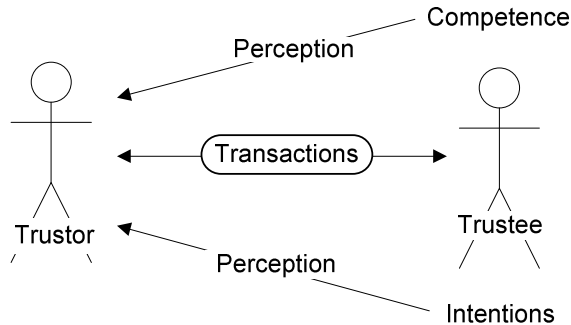
Figure 3: Forms of trust

It can be concluded that there are two forms of trust. One can trust in the *intentions* (goodwill, honesty etc.) of the trustee and one can trust in the *competence* of the trustee.

2.2 Trust in the e-business environment

Any business transaction takes place in an environment. The four-layer model by Williamson describes the position of transactions in this environment, or the institutional world. Williamson states that several institutional aspects of the environment influence the way transactions are handled. First a definition of institutions by North: "*Institutions are the rules of the game in society, or, more formally, are the humanly devised constraints that shape human interaction.*" (North, 1990, p. 3)

Williamson divides the world in four layers, which can be seen in Figure 4. At the lowest level actors interact with each other; this is where transactions take place. On the second level there are specific institutional arrangements between groups of actors, which influence the way in which business is done. On the third level there is the formal institutional environment, which is created by formal rules, laws etc. These laws and rules define the rules by which actors can interact and by which agreements amongst actors can be made.

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┌─────────────────────────────────────────────────┐
│  Layer 4: Informal institutional environment of socio- │
│                technological systems               │
│         Norms, values, orientaties, codes          │
└─────────────────────────────────────────────────┘

┌─────────────────────────────────────────────────┐
│   Layer 3: Formal institutional environment of socio- │
│                technological systems               │
│   Formal rules, laws and regulations, constitutions. │
└─────────────────────────────────────────────────┘

┌─────────────────────────────────────────────────┐
│        Layer 2: Formal and informal institutional  │
│       arrangements of socio-technological systems  │
│   Gentleman agreements, covenants, contracts,      │
│        alliances, joint-ventures, mergers, etc.    │
│   Informal: rules, codes, norms, orientation, relations │
└─────────────────────────────────────────────────┘

┌─────────────────────────────────────────────────┐
│   Layer 1: Actors and games in socio-technological │
│                     systems                        │
│    Actors/agents and their interactions aimed at   │
│  creating and influencing (infrastructural) provisions, │
│              services, outcomes                    │
└─────────────────────────────────────────────────┘
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Figure 4: The four-layer model: levels of institutional analysis. Adapted from (Koppenjan & Groenewegen, 2005)

At the highest level there are the informal institutions. These institutions are the norms and values or the ideas on ethics often based on religion or political views. These informal institutions influence the decisions on rules, laws and regulations, but also influence the way business is done.
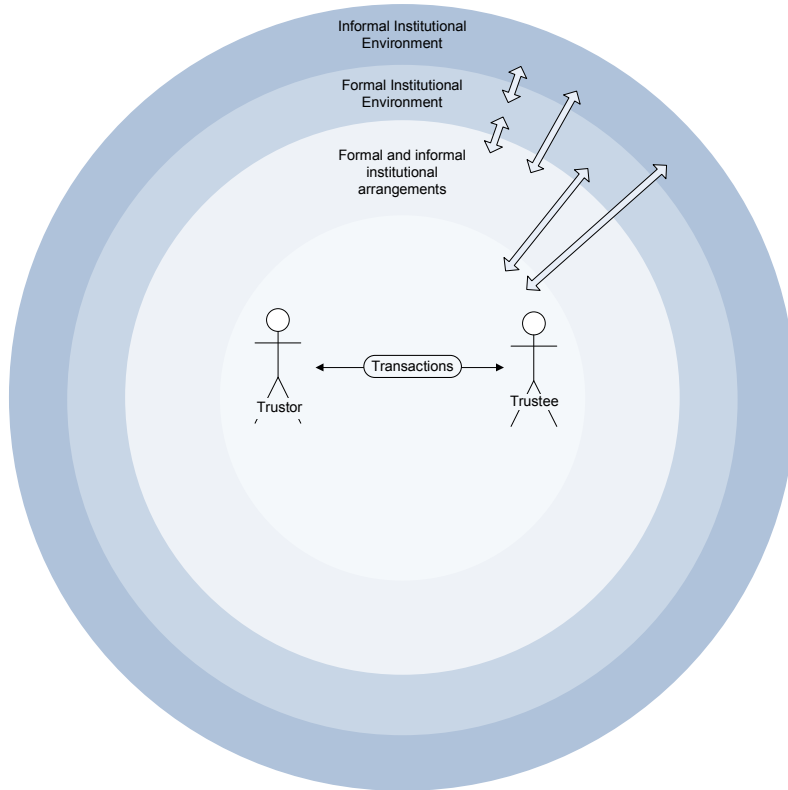
Figure 5: Transaction in the environment

A transaction takes place in this environment. This means that it is influenced by all the institutions around it. This is depicted in Figure 5: Transaction in the environment. Trust, as part of the transaction, is also influenced by these layers. This means that this environment should be included when designing systems to incorporate trust in eBusiness transactions.

2.3 Foundations of trust

Where does trust come from and on what is it based? Most scholars have ideas on this and possibly the most influential writers on this topic are Luhmann and Zucker. In her influential 1986 paper on the production of trust Zucker (1986) identifies three modes of trust production: institutions-based trust, process-based trust and characteristic-based trust. These three modes of trust production are taken as the basis of the analysis in this chapter, as they match the four layer model by Williamson. The transactions between actors and their outcomes provide the basis of process-based trust. These processes take place in layer 1. Formal institutions, such as laws and agreements, are the foundation of institutions-based trust. These institutions can be found in both layer 2 and 3, where layer 2 contains the inter-organisational institutions and layer 3 contains the regulatory institutions. Characteristics-based trust is based on layer 4 of the model. A literature review was done to check whether these three modes of trust production are exhaustive.

Appendix A gives an overview of the foundations of trust per author. The table below is a clustering of all the foundations of trust mentioned in those articles, grouped where possible with Zucker's modes.

Institution-based	Process-based	Characteristics-based	Other

Institution-based	Process-based	Characteristics-based	Interpersonal Trust
Systems Trust	Reputation-based	Personal	Personality-based trust
Institutionalized processes-based	Knowledge-based	Relationship-based	Cognition-based trust
Impersonal		Identification-based	
Deterrence-based		Norms and Culture	
Incentive-based trust			
Calculus-based			

Table 2: Clustering of Foundations of trust found in literature

The table above has Zucker's three modes of production in the top row. Each other foundation of trust in literature was compared to these three. This comparison is described below in the same order as in the table.

Institution-based trust is the type of trust gained from political or economic systems or formal institutions. Examples thereof are certifications, intermediaries or judicial systems.

The following foundations of trust have been clustered with institution-based trust.

> **Systems Trust** is first described by Luhmann (1988). According to Luhmann system trust is the trust one places in the judicial system surrounding the transaction. This is essentially a part of institutions-based trust as described above. This is also confirmed by Bachmann (2001).

> **Institutionalised processes-based trust** is mentioned by Ratnasingham (2001). He points to Zucker for a definition. This is thus nothing else then another term for institutions-based trust.

> **Impersonal Trust is** described by Shapiro (1987). According to Shapiro impersonal trust is not embedded in personal relations. It "describes a kind of social organization." (Shapiro, 1987, p. 625). These are also included in institution-based trust as intermediaries.

> **Deterrence-based trust** is based on the threat of a punishment when the trust is violated (Ratnasingham, 1998). This threat can come from two sources, from a contract or from the institutional system. In the first case, it is not trust, but control. In the second case it is equal to institutions-based trust.

> **Incentive-based trust** is based on the awarding of a bonus when the transaction is completed successfully. As it also comes from contractual agreements or from the institutional system, this is essentially the opposite of deterrence-based and is also part of the Institution-based trust.

> **Calculus-based trust** is based on full rationality, where actors become predictable, as their actions can be calculated from knowledge of the costs and benefits of each choice (Maguire, Phillips, & Hardy, 2001, p. 289) and Ratnasingham states that it is the same as his deterrence-based risk.

The second foundation of trust defined by Zucker is *process-based trust*.

Process-based trust is based on "past or expected exchange such as in reputation or gift-exchange." (Zucker, 1986, p. 60).

The following foundations of trust have been clustered with process-based trust.

> **Reputation-based trust** is obtained second-hand. As reputation is literally mentioned in Zucker's definition, it is clear this should be clustered.

> **Knowledge-based trust** is based on knowledge acquired from observation of the trustee (Maguire et al., 2001, p. 289). It is thus based on past exchange and can be clustered with process-based trust.

The third foundation of trust defined by Zucker is *characteristics-based trust*.

Characteristics-based trust is trust "tied to person, depending on characteristics such as family background or ethnicity" (Zucker, 1986, p. 60).

The following foundations of trust have been clustered with characteristics-based trust.

> **Personal trust** is another term for characteristics-based trust used by both Bachmann and Williamson, who cite directly from Zucker to define it (Bachmann, 2001; O.E. Williamson, 1993).

> **Relationship-based trust** is based on "social relationships and embedded ties." (Ratnasingham, 2001, p. 33). It is another example of characteristics-based trust. In this case the trustor trusts the trustee, because they share for example a family bond.

> **Identification-based trust** is based on the understanding of the others norms and values and thereby his 'desires and intentions' (Maguire et al., 2001, p. 290; Ratnasingham, 1998). As the norms and values are specific characteristics of the trustee largely dependent on family background and ethnicity, this is clustered with characteristics-based trust.

> **Norms and Culture based trust** is trust based on shared norms and culture. As said with the previous type, this can also be clustered under characteristics-based trust.

There are now a few types of trust left over, which cannot be caught in Zucker's categorisation. These are interpersonal, personality-based and cognition-based trust.

> **Interpersonal trust** is not so much a foundation of trust, but more a kind of trust, the trust that exists between two actors. The authors contrast it with institutions-based trust (Knights, Noble, Vurdubakis, & Willmott, 2001, p. 314), so it could be a combination of Zucker's process-based and characteristics-based trust, but no clear definition is given. Due to the lack of clarity this is not used any further.

> **Personality-based trust** is described as follows: "[..]personality-based trust [..] develops during childhood [..], resulting in a general tendency to trust others." (McKnight, Larry, & Norman, 1998, p. 475). This means it is some sort of baseline trust rooted in a person, who gives a certain level of trust to everyone. This is not really a foundation of trust. Other authors also recognise this concept and call it 'Disposition to trust' (McKnight et al., 1998, p. 475) or something similar. This is an important concept, which will return later.

> **Cognition-based trust** is based on "rapid, cognitive cues or first impressions" (McKnight et al., 1998, p. 475). This type of trust is very personal and should not be included in interorganisational trust models.

Concluding it can be stated that Zucker's 1986 paper was very influential and not without a reason, as according to the analysis in this section it is quite complete.

Her definition of three modes of trust production seems to be exhaustive, as all other modes of trust production can be divided amongst them or be discarded.

2.4 Conclusions

The literature study presented here was extensive, but is by far not exhaustive. Nonetheless there are sound results which can be used to build solutions on. Trust is best defined by the combination of two definitions. The first one states that trust is "a psychological state comprising the intention to accept vulnerability based upon positive expectation of the [..] behaviour of another" (Rousseau, 1998, p. 395). Trust is also "a four-place predicate: the trustor (1) trusts a trustee (2) in one or more aspects of behaviour (3), under certain circumstances (4)" (Nooteboom, 2005, p. 66).

For the following chapters it is important to note that there is a distinction between trust in *intentions* and trust in *competence*. Trust in *intentions* is the expectation that the transaction partner is planning to perform his part of the transaction to his best ability. Trust in *competence* is the expectation that the transaction partner has the necessary competences to perform his part of the transaction.

Secondly there is a distinction between the different foundations of trust: *process-based* trust, *characteristics-based* trust and *institutions-based* trust. An important factor in trusting behaviour is also the *disposition to trust*, which is the basic stance towards trust and defines whether an actor is trusts easily or not. In all cases it is important to remember that a transaction takes place in an institutional environment and the influences of those institutions have an impact on the transaction. In the next chapter the theory found here will be translated into practice. The theory will be applied to a business environment and will facilitate the design of the framework.

3   Operationalising trust

In the previous chapter an overview was given of sociological and economic insights in trust. In this chapter the foundations of trust described earlier are used to illustrate the process of trust and its place in the environment. Using this knowledge it becomes possible in later chapters to decide what parts of trust can be implemented in an online environment.

3.1   Process of building trust

Trust is not a constant, but it changes over time. In the previous chapter the different constructs of trust were found: characteristics-based, process-based and institutions-based trust. The question is how they operate together over time. Several authors have written about the process of trust. For example Mayer has proposed an integrative model of the trust process (Mayer, Davis, & Schoorman, 1995) and McKnight et al. have written on the process of initial trust formation (McKnight et al., 1998). As both models have different objectives, they are quite different. These models do however not include the constructs found in the previous chapter. Therefore it was decided to build a new model of the process of trust. The model is discussed in this paragraph step by step. We start out with two actors who are unfamiliar with each other: the trustor and the trustee. They want to perform a transaction.
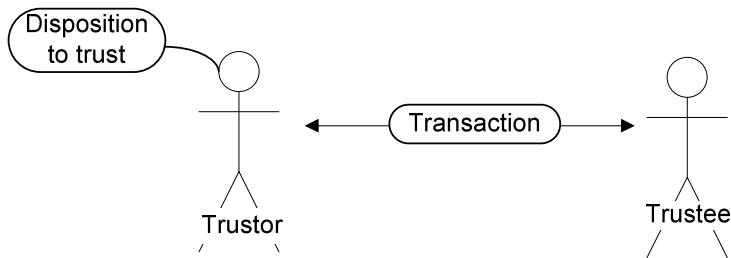
Figure 6: Initial situation

Let us assume that the two actors have not transacted before and have no other sources of information about the trustworthiness of the other person. In this case there is only one construct of trust used, which is the disposition to trust or "the general tendency to trust others" (McKnight et al., 1998, p. 475). If this disposition is high enough, the trustor will initiate the transaction with the trustee. After the first transaction, the situation changes into a situation where the actors have information about the trustworthiness of the other.
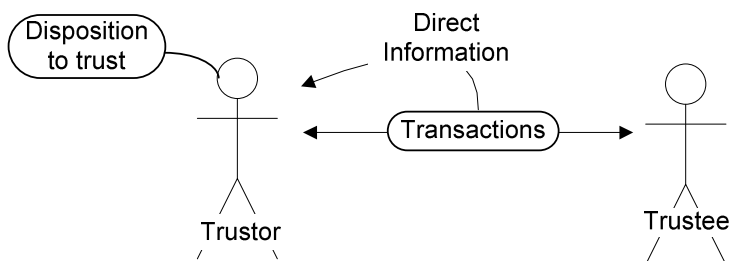
Figure 7: Situation after first transaction

In this situation the trustor now knows the outcome of previous transactions. If those transactions were successful, the trust level has increased; otherwise the level of trust has decreased. By performing more transactions, the trustor gathers more information about the trustee and will get a better approximation of his

trustworthiness. This is so-called *direct information*. We can now introduce other actors into the process as displayed in the following figure.
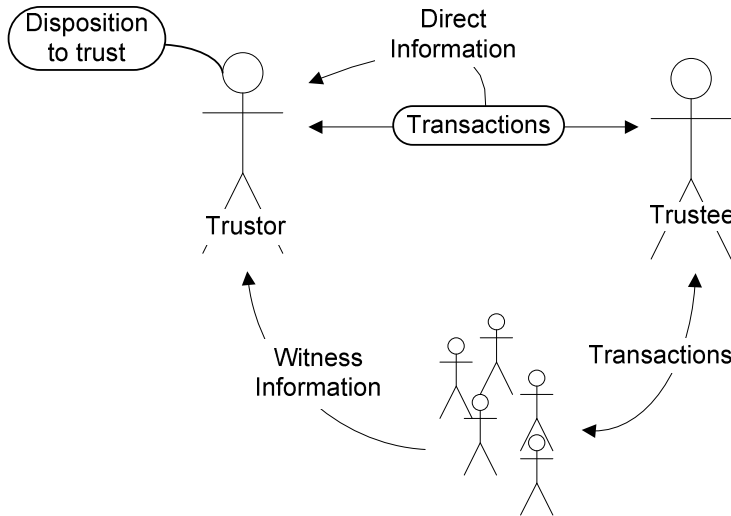
Figure 8: Introduction of witnesses

Now there are new actors, who perform transactions with the trustee. They gather information on the trustworthiness of the trustee, just as the trustor does. They can now share that information with the trustor and thus increase his knowledge about the trustee. Once again more information means a better approximation of the trustworthiness of the trustee. This kind of information is called *witness information*. Both these types of information are part of the process-based trust. Now a new actor can be introduced: the expert.
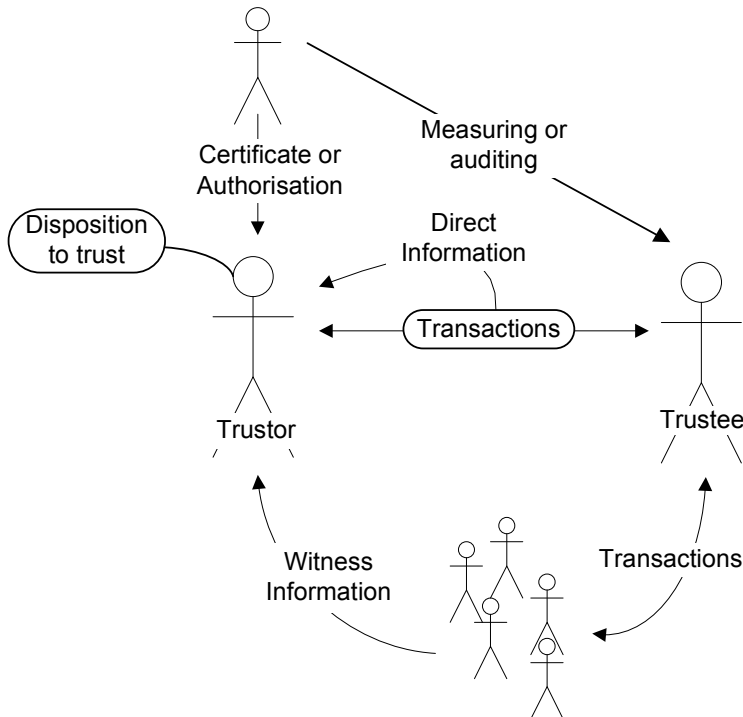
Figure 9: Introduction of Expert

The expert is an external organisation, who has access to inside information of the trustee. He gathers this information from measurements or auditing performed at the trustee.

This figure can be placed in the four-layer model by Williamson. This is done in the figure below. The transaction is placed in the centre, which is the layer where 'the game is played' (layer 1). This transaction and the arena in which it is played, is influenced by all surrounding layers. The expert or certification authority is an institutional solution. It is placed in layers 2 and 3, where it is organised and grounded in contracts, regulations and/or law. Once again this is influenced by all other layers in the model.
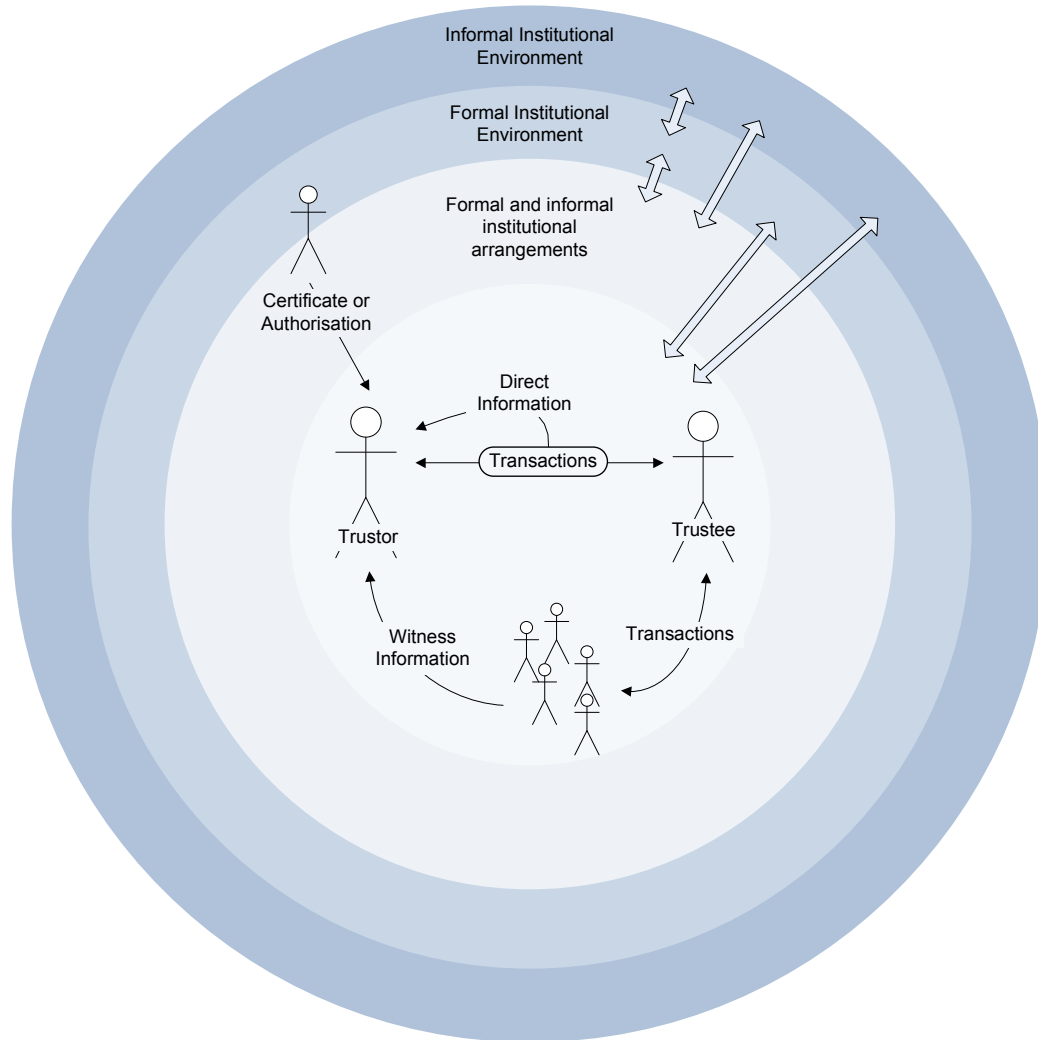
Figure 10: Trust in the environment

An important thing to learn from this picture is that the different layers always influence the transaction. All formal and informal institutions influence the transaction and the trust level. When designing a trust system, these influences should be analysed and where possible incorporated into the design.

3.2 Categories of transactions

Williamson is one of the premier economists in the field of transaction economics. He has recognised three characteristics of transactions which determine the governance model best suited for that transaction. These are *Asset Specificity*,

Frequency, and *Uncertainty* (Oliver E. Williamson, 1979). The advantage of using these characteristics is that there is an abundance of information available on how to assess these characteristics.

The *asset specificity* is a measure for how specific the assets needed for the transaction are. An example: a machine that can create 45nm microprocessors such as the latest CPUs[2] is a highly specific asset, which is not readily available (this machine is called a lithography machine). A machine that can produce single-layer PCBs[3] on the other hand is not a specific asset, as these machines are standard and relatively cheap. Another side of asset specificity is how easily the asset can be used for something else. Another example: a container truck is nonspecific, as it can be used to transport nearly anything. On the other hand Airbus has trucks, which are specifically built for the transportation of airplane wings from one factory to the other.

The *frequency* is a logical term. It describes the frequency with which a transaction takes place. Let us go back to the example of containers and airplane wing. Every day millions of containers are transported all over the world. Airplane wings are not transported that frequently, maybe one or two each day. There are even transactions which only occur once, unique transactions. An example is the lithography machine mentioned earlier. Every machine is unique and built to the specifications of the customer, so every transaction is unique.

There are two types of frequency: the internal and the external frequency. While a certain transaction can be very common for one player in the market (it has a high internal frequency), the transaction can be unique in the market (it has a low external frequency). Buying a car is an example of the opposite: the transaction has a low internal frequency (once in every five years), but a high external frequency (hundreds of cars sold every day). This means that there are 4 different situations possible, depicted in the following diagram.

		External Frequency	
		Low	High
Internal Frequency	Low	Highly Specific Transaction	Internally specific transaction
	High	Externally specific transaction	Nonspecific transaction

Table 3: Different types of frequency in a transaction

The *uncertainty* is the third factor. According to Williamson this is one of the investment characteristics, together with the asset specificity. The uncertainty has several sides. It says something about the risk, or the potential losses, involved with the transaction, but it also says something about the complexity of the transaction. In a complex transaction there is always some uncertainty concerning the specifications. The uncertainty thus concerns the chance that the outcome of a transaction is not as planned in advance.

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[2] Central Processing Unit: The core of any computer, a wellknown example is the Intel Pentium CPU.

[3] Printed Circuit Board: the board that connects all electric components to each other in any electronic device.

Figure 11: Model of efficient governance (Oliver E. Williamson, 1979)

Figure 11 shows the model proposed by Williamson to choose for certain types of governance based on characteristics of the transaction. Now follows an example to clarify the figure.

A well-known example is that of a car manufacturer, which is reconsidering its outsourcing strategy. They currently manufacture their own tyres for all the cars they make. Their question is whether that is a good strategy or not. They now have to look at the transaction characteristics: the investment characteristics and the frequency of the transaction. What are the assets needed for producing tyres and how specific are they? Well, a tyre-making machine is very specific and cannot be used for anything else. Secondly a look at the uncertainty is needed. A car tyre is a quite simple product, with a limited set of specifications that can be checked without a lot of effort. We can thus conclude that the investment characteristics are mixed, which points us to the middle column of the figure. There are now two choices left: trilateral governance and bilateral governance. This decision has to be made based on the frequency of the transaction. A car manufacturer needs 5 tyres per car (4 wheels and a spare tyre) and produces 10 million cars every year[4], bringing us to a grand total of 50 million tyres. Clearly this is a recurrent transaction and not an occasional transaction. With this extra piece of information we are pointed towards bilateral governance or contracting.

This model has inspired the idea that a similar model can be made for the choice of a trust system. The first step is to analyse the differences between the different trust systems and try to find out what requirements they have for the environment to work properly. Secondly each of the transaction characteristics, *Asset Specificity*, *Frequency*, and *Uncertainty,* will be mapped on those requirements.

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[4] 10 million is an estimate based on the worldwide sales of Toyota

4 Exploring the solution spaces

Koppenjan and Groenewegen suggest that there are three distinct types of design in complex technical systems: technical design, institutional design and process design (Koppenjan & Groenewegen, 2005). The process design defines the process by which the other designs are made, by defining "who participates in the design process, what the conditions are, the rules, roles, items, steps etcetera" (Koppenjan & Groenewegen, 2005, p. 243).
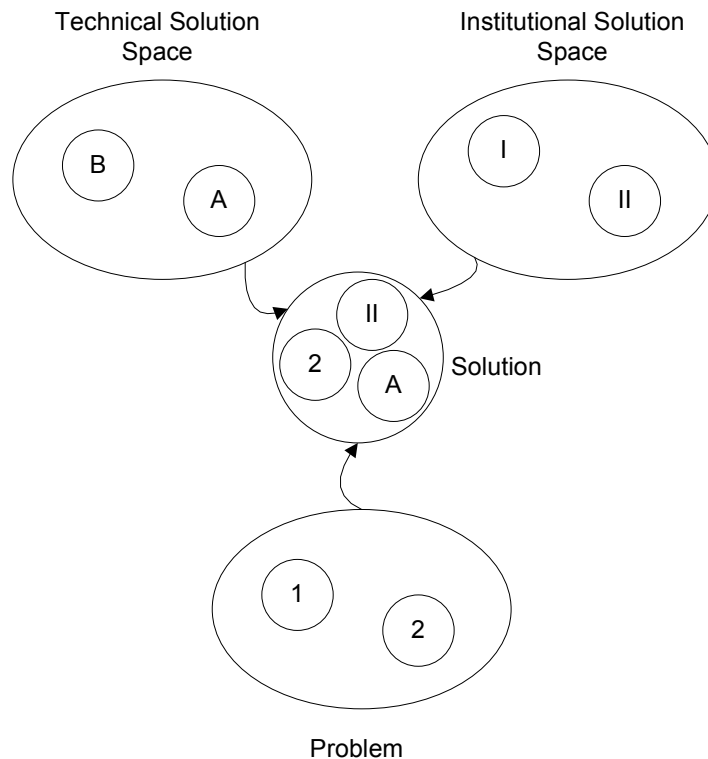
Figure 12: Solution spaces

The goal of the design framework is to guide the users to a design. The design framework provides a set of decisions and guides the users in making these decisions. The result of using the framework is a clear set of requirements for the system to be built. This result is reached in a few steps:

1. Analyse the transaction at hand to find its main characteristics
2. Find out which type of trust system fits best to these characteristics
3. Describe technical requirements for the chosen trust system
4. Describe institutional requirements for the chosen trust system

The first step towards this framework is to analyse the three spaces: the problem space and the two solution spaces. If it is clear which solutions are available and what problems exist, it is then possible to couple solutions to problems, which is exactly the goal of the design framework. Previous chapters discussed the problem space. In this chapter the solution spaces for the technical and institutional design will be discussed.

4.1 Requirements for technical solutions

In chapter 3 Figure 9 a trusting transaction was shown in its environment. This transaction is again depicted in Figure 13. In this figure two different systems can be recognised. One is a reputation-based system, which works based on

information obtained from previous transactions by either the trustor or witnesses available on the internet. The other is a certification system, where a 'trusted third party' gives out a 'certificate of trustworthiness' based on some relation with the trustee.

In the following paragraphs the requirements for each of these systems will be discussed.
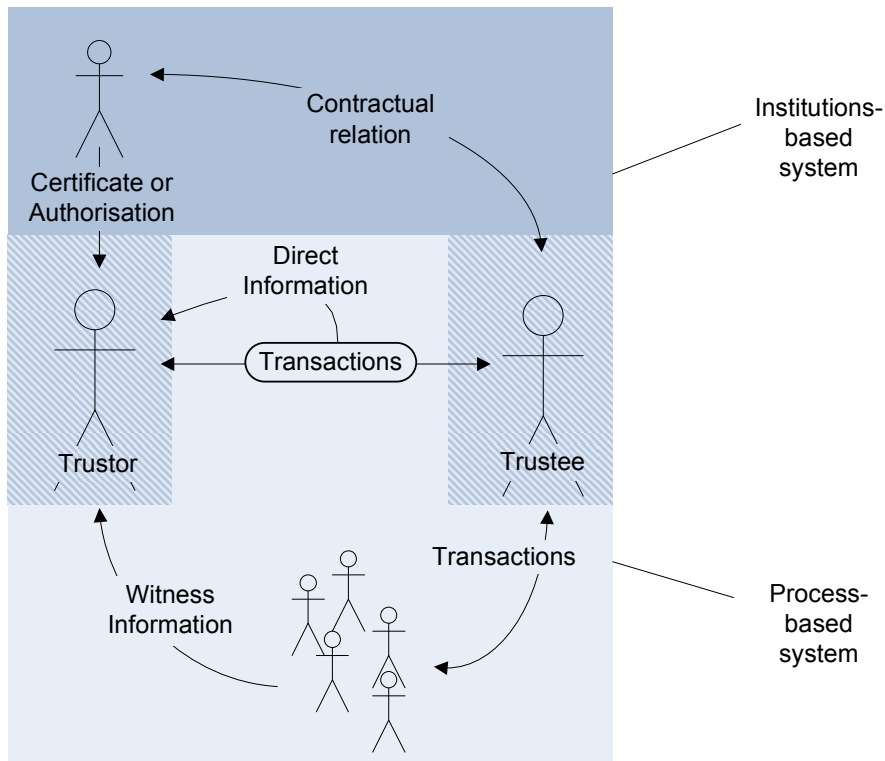
Figure 13: Systems in trust relations

4.1.1 Process-based system requirements

The process-based trust in this model is a reputation-mechanism. The system works on an individual basis, as every trustor has a different view on trust and reputation. In Figure 13 the reputation-based system is coloured in a lighter shade blue. There are two different information sources. The first source is the transactions between the trustor and the trustee, while the second source is the witnesses who have done transactions with the trustee. For now these two will be discussed as separate systems.

In the case of a direct information system, there has to be a system in place to collect (a) and store (b) the transaction information. When the information has been stored, there should be a system in place to select information based on the identity of the trustee and the current context (c), where the context is the circumstances in which the transaction takes place. Using the selected information a trust level has to be calculated (d).

In the case of a witness information system, there should be a system to collect (a) and store transaction (b) information at the witnesses. The trustor should be able to search for this information based on the identity of the trustee and the current context (e). Lastly the trustor has to be able to calculate a level of trust based on the found information (f).

It is possible to combine the direct information and the witness information. In this case all of the above remains true, but the system should also be able to calculate a trust level by combining the trust levels in the direct information system with that of the witness information system (g).

The system should...

    a. Collect transaction information.

    b. Store transaction information

The Direct information system should…

    c. Search and select information based on identity of the trustee and a given context.

    d. Calculate a trust level based on selected information.

The Witness Information system should…

    e. Search and select information based on identity of the trustee and a given context.

    f. Calculate a trust level based on the selected information

A combined system should…

    g. Calculate a trust level based on both direct and witness trust levels.

In the case of a witness information system the question remains whether the system should be centralised, decentralised or a hybrid form. There are four archetypes of trust models: *Central Hierarchical*, *Central Peer*, *Decentral Peer* and *Meshed Hierarchical* (Daskapan, 2005). All have their advantages and disadvantages, which are also described by Daskapan. The *central hierarchical model* consists of a central node, which is responsible for the distribution of trust. This central node is hierarchically placed higher than the other nodes. This system is vulnerable due to its single point of vulnerability and the single central trusted node, which is not necessarily trusted by all actors. The *central peer model* is different from the central hierarchical model in that the central peer has no hierarchical relation to the other peers. Nonetheless it suffers from the same weaknesses as the central hierarchical model. The *decentral peer model* is a completely decentralised model, where each actor is both a trust distributor and a trust user.

The *meshed hierarchical model* is a model in which there exist multiple central hierarchical nodes with their own hierarchical tree. These different trees can then be coupled on any level in the tree by bridging nodes or by trusting more than one central node.

The choice between the different levels of centrality is one that cannot be made in advance and is dependent on the situation at hand. Therefore this is not part of the requirements.

4.1.2 Institution-based system requirements

The institutional trust is translated into the technical world as a certification system. It is depicted in Figure 13 in a darker shade. A third party gives out certificates to testify his trust in the trustee. The technical requirements for this system are quite straightforward, based on the workings of such a system. The trustee has a certificate, which he can then communicate to trustors (a). The trustor checks the certificate with the certifying authority (b). The certificate provides a certain level of trust (c) and specifies the context in which this level of trust holds (d).

The system should…

    a. provide a means for communicating certificates.

    b. provide a means for checking certificates.

    c. support different levels of trust.

    d. provide a means to communicate the context.

4.2 Existing technical solutions

4.2.1 Process-based solutions

A short literature scan has revealed thirteen different models and systems for managing trust based on reputation in digital environments. This paragraph proposes a classification for process-based trust solutions and places existing solutions into this classification.

Comparison

The existing trust solutions can be compared on several features. This classification clarifies the distinctions between the solutions and aids in defining requirements. Sabater and Sierra (2005) and Wang and Vassileva (2007) have done work before on identifying distinctions between reputation systems. The work presented here is partly composed from their work.

Algorithm and/or Architecture

A review of the available literature reveals that trust models comprise two distinct factors. Some models describe how experience or reputation information can be shared amongst agent in the system. These models for example propose using WS-Policy (an XML-standard) as the envelope for reputation messages in a centralised architecture (Coetzee & Eloff, 2006), while others propose a 'service agent' which stores reputation information (Lages, Pirmez, Pires, & Delicato, 2007). On the other hand there are computational algorithms, which propose a (set of) formula(e) for computing trust levels.

In the end both are needed for a proper functioning system. At the one hand formulae are needed to calculate trust levels, but on the other hand information about agents needs to be shared and stored using some kind of architecture. It is useful to use this distinction in the treatment of the models.

For the final design both are needed to have a properly functioning environment.

Centralised or decentralised

The architectures amongst the trust models can be split in two separate groups. One group uses a centralised architecture, in which reputation is stored by a dedicated agent. Examples hereof are the 'service agent' (Lages et al., 2007) and the 'trust manager' (Coetzee & Eloff, 2006). In the other group trust or reputation information is stored by every agent and shared in a decentralised fashion, for example by using Gnutella protocols (Yu, Singh, & Sycara, 2004).

Single-context or multi-context

When defining trust, it became apparent that the trustor trusts the trustee *under certain circumstances*. Some of the trust models include this in their model and can generate different trust levels to the same agent in a different context. Other models can only generate one trust level for an agent. Following Sabater and Sierra (2005) a multi-context model supports different trust levels, while a single-context model supports only one generic trust level per agent.

Global or Personal

Imagine a situation with three agents Alice, Bob and Charlie. If Alice would deem Charlie very trustworthy, would Bob deem Charlie just as trustworthy? In the sociological literature trust is personal. Alice and Bob are different and have different norms and values to judge Charlie by. Amongst the trust models there are some which threat trust as a global property, such as the eBay-model (Fahrenholtz & Lamersdorf, 2002). Others threat it as a personal property, which is calculated by the trusting agent itself.

Information Sources

Sabater and Sierra (2005) identify four different sources of information that can be used to calculate a trust level. First of all there is *direct experience* or personal information. If Alice has had a transaction with Bob in the past, she has some knowledge about his trustworthiness. Secondly there is *witness information*. Let us say that Alice has never done transactions with Bob and Charlie did have previous transactions with Bob. In this case Charlie could give Alice information on the trustworthiness of Bob. The question that remains is how much Alice trusts Charlie. Lastly Sabater and Sierra recognise *sociological information* and *prejudice*, in which sociological information is information about the role of an agent in a group or the relationship between different agents (Sabater & Sierra, 2005, p. 36). Prejudice is based on the membership of an agent of a certain group (Sabater & Sierra, 2005, p. 37) and is equal to Zucker's Characteristics-based trust.

	Algorithm or Architecture	Centralised or Decentralised	Single- or multi-context	Global or Personal	Information Sources
Abdul-Rahman (Abdul-Rahman, 2004; Abdul-Rahman & Hailes,	Arch + Alg	Decentralised	Multi	Personal	Pi+ Wi
Coetzee (Coetzee & Eloff, 2005, 2006, 2007)	Arch	Decentralised	Single	Personal	Pi+ Wi
Fire (Huynh, Jennings, & Shadbolt, 2004a, 2004b)	Alg	Decentralised	Multi	Personal	Pi+ Wi
Histos (Zacharia & Maes, 2000)	Alg	Centralised	Single	Personal	Pi+ Wi
Marsh (Marsh, 1994)	Alg	Decentralised	Multi	Personal	Pi
Mui (Mui, 2002; Mui, Mohtashemi, & Halberstadt, 2002a, 2002b)	Alg	Decentralised	Single	Personal	Pi + Wi + Prej
Regret (Sabater-Mir & Paolucci, 2007; Sabater & Sierra, 2001, 2002,	Alg	Decentralised	Multi	Personal	Pi + Wi + Soc Prej
Satya (Lages et al., 2007)	Arch	Centralised	Single	Personal	Wi
SECURE (Cahill et al., 2003; Huang & Bracher, 2005)	Arch	Centralised	Single	Personal	Wi
Sherchan (Sherchan, Loke, & Krishnaswamy, 2006)	Alg	Centralised	Single	Global	Wi
Sporas (Zacharia & Maes, 2000)	Alg	Centralised	Single	Global	Wi
Wang and Vassileva (Wang & Vassileva, 2003, 2004)	Alg	Decentralised	Multi	Personal	Pi+ Wi
Yu and Singh (Yu & Singh, 2002; Yu et al., 2004)	Alg	Decentralised	Single	Personal	Pi+ Wi

Table 4 Trust model Comparison

Founding Trust in an eBusiness Environment

4.2.2   Institution-based solutions

Certificates are commonly used in the world of information security and thus the online world. The most commonly used certificates are based on the X.509 standard. The X.509 standard provides the definition of the certificate, including a 'subject field' that can be freely used, a system to distribute the certificates and a system to revoke certificates.

As X.509 is an accepted standard, it is deemed unnecessary here to investigate alternatives.

4.3   Existing Institutional solutions

Institutions are the rules and regulations that ensure the proper functioning of any group of actors. In the case of an online B2B environment, there is a network of actors, who want to cooperate in random combinations. Those actors also need rules and regulations to create an environment in which they can do their business. The trust enhancing technologies presented earlier can not work without their own set of rules. These rules should for example prescribe who is responsible for the workings of the system, what the specifications of the system are or even how to deal with abuse of the system. The fact that the systems operate in a B2B environment makes it more difficult. Normally there is no hierarchy in a business environment, as companies are equal business partners. Designing institutions in such a networked world is not an easy task.

De Bruijn and Ten Heuvelhof (1995, 1999) argue that in a networked world the actors have for distinct properties, which make them hard to rule. First of all, the actors are *interdependent*. This means that the actors in the network are dependent on each other in one or more ways, for example financially. Secondly the actors are *pluriform*. In a network, no two actors are the same and they all have their own needs, but are also sensitive to different incentives when they need steering. Thirdly there is *self-containment*. Actors in the network have their own norms and values and are therefore partially closed to incentives and steering from outside. The last feature of a network environment is *instability*. Networks change all the time, as new actors join the network, while others disappear from the network. Even changes in the strategy of companies might affect the structure of the network.

Any institution designed to work in such a network environment should accept these features of a network and act accordingly. In the remaining of this chapter the institutions needed for both the reputation-based and certificate-based system will be discussed, other then the ones discussed above.

4.3.1   Process-based trust institutions

Process-based trust systems need institutional support. Let us recall what such a system does. It provides a means to communicate information about the trustworthiness of a transaction partner. It provides a level of trustworthiness and a context in which this level is true. So what would the role of institutions be? First of all arrangements have to be made to ensure the operation of the system. A new organisation can be created to supervise the creation and operation of the system or an existing organisation can be appointed this task. Secondly there is the specification of the information that is to be exchanged. What does a certain level of trust mean? Which are the contexts that can be communicated? Some organisation or task force should be assigned this responsibility.

Furthermore it is important to have a system to cope with complaints. Any system like this will be abused at some point in time. Having a procedure in place for receiving and processing complaints is a necessity to maintain the trust of the users in the system.

An example of the types of responsibilities to be assigned are:

- Responsibility for the creation of the system
- Responsibility for the operation of the system
- Responsibility for the specification of the system
- Responsibility for the handling of complaints

And the following rules have to be established:

- What happens in the case of a abuse
- Who can use the system
    - Users of the trust value
    - Users who can leave witness information

In a later chapter it will be investigated whether or not these responsibilities and rules can be based on transaction characteristics.

4.3.2 Certificate-based trust institutions

Certification is an existing institutional tool. The normal institutional arrangements for certification existing in the offline world also hold for the online world. These include for example the need for certification standards, rules on certifying parties, complaint procedures etc. Some additional arrangements have to be made for support of the online system, such as the responsibility for the operation of the system.

4.4 Conclusions

Looking at the solution spaces for the two different types of trust, it becomes apparent that there is a major difference between the two. Certification is a standard institution in the offline world and there already is a standard for online certificates. The step towards combining these two is small. Process-based systems are different. Reputation is not organised in the offline world and thus no institutions exist to support it. In the online world reputation is still being researched and no standard has been formed yet. This means that the institutions for process-based systems still need to be designed. In this chapter the baseline responsibilities and rules for those institutions have been identified.

In the technical solution space there are three main solutions: reputation systems, which are split in Direct Information and Witness Information systems and as a third solution certification schemes based on institutions-based trust. These three can be combined at will. In the next chapter an attempt is made to couple the problem space to the two solution spaces.

5 Towards a Trust Framework

The question remaining is which technologies to choose in different situations. The problem space has been defined in chapter 3 and the solution spaces in chapter 4. In this chapter an attempt is made to map these. Every type of transaction has different characteristics and so does every market. In chapter 3 different types of markets were specified based on Williamsons TCE model. Each of these types of markets has its own characteristics, which lead to the use of a certain kind of trust technology and institutions. This will also be discussed in this chapter.

5.1 Differences between trust systems

Direct Information-based reputation

In the case of direct information, there are two factors to take into account: the gathering of information and the amount of risk one's willing to take based in this information. First of all it is necessary that the trustor, the trusting party, can *collect information* about the transaction partners. This means the trustor needs to have regular transactions with the different suppliers, just to be able to build an opinion. On the risk side there is the problem that the first transaction cannot be based on trust. This means that only based on trust levels the first transaction must have a low risk. In later transactions the acceptable *level of risk* of a transaction is proportional to the amount of information available.

Witness Information-based reputation

In the case of witness information there are several issues to address, of which two are the same as with direct information: the *gathering of information*, the *amount of risk* one's willing to take based on the information and the trustworthiness of the witnesses. Information is gathered by witnesses, which means that the witnesses should have regular transactions with the trustee, the trusted party. On the risk side there is the same problem with the first transaction as with the direct information. Again the acceptable level of risk is proportional to the amount of information available. A new factor to take into account is the *trustworthiness of the witnesses* and the information they share. Information retrieved from witnesses is not necessarily correct. This means that the level of risk one can take based in the witness information is limited by the trustworthiness of the witnesses.

Certification

In the case of certification other factors play a role: *standardisation*, *level of risk* and *trustworthiness of certification*. A certificate certifies the compliance to a certain standard. This means that some *standardisation* needs to be possible for the transaction at hand, before certification can be used. The *level of risk* is proportional to the trustworthiness of the certification. The trustworthiness of the certification is dependant on several different factors.

The first prerequisite of certification is that the certifiable object can be measured. This means that there have to be prescriptions on what to measure, how to measure and benchmark levels. The certifying institute needs sufficient access to the object to be measured and thus perform the measurements. Further more the certification needs to be developing or learning. Coping with a changing environment, changing demands and developing products needs to be a fixed part of the certification scheme. Just so an important part of any certification scheme is a proper complaint procedure, to ensure that certified products keep up their high standards after certification.

Combining the decision factors found in the descriptions above, the following are found:

- Possibility to gather information
- Risk level
- Trustworthiness of witnesses
- Trustworthiness of certification
- Standardisation

In the next section these factors will be mapped to the three transaction characteristics.

5.2 Mapping characteristics to trust factors

There are now two lists of factors: the transaction characteristics by Williamson from chapter 3 and the decision factors on trust systems.

Asset Specificity is the specificity of the assets needed for the transaction. Does this influence the choice for a trust system? In a simplified world there are two cases: high specificity and low specificity. What can be said about the five decision factors in the case of high asset specificity? In this case there are few suppliers who own the necessary assets. Fewer suppliers means that gathering information is easier, but that does not aid a choice between the systems. In the case of low asset specificity there are a relatively large number of suppliers. This makes it harder to gather information in a Direct Information-based system. The asset specificity does not influence the four other decision factors. This means that asset specificity can only be used to exclude Direct Information-based systems in the case of low asset specificity.

Then there is the *frequency* of the transaction. Earlier four different situations were recognised: nonspecific, internally specific, externally specific and highly specific transactions. In the table below the four cases are again displayed, but this time the preferred trust systems are inserted.

		External Frequency	
		Low	High
Internal Frequency	Low	No use for trust.	Witness Information or Certification
	High	Direct Information	All systems work

Table 5: Different types of frequency in a transaction

If the transaction is highly specific (low internal and external frequency), a separate trust system for this transaction is of little use. One might be able to use a generic, context independent trust system, which is not specific to the transaction, but does say something about the transaction partner in generic transactions. In the case of an externally specific transaction (high internal, low external frequency) the direct information is the best system. Information is abundant inside the organisation, but outside the organisation the transaction is uncommon, so witness information is rare and an external certification authority is expensive.

The case if internally specific transactions (high external, low internal frequency) is the opposite. There is little to no information inside the organisation, so witness information and/or a certificating authority are better sources for a trust value. In

the nonspecific transaction (high internal and external frequency) there is no clear preference for any of the systems.

The last transaction characteristic is the uncertainty. Uncertainty brings with it a high risk level, which is one of the decision factors. A high risk level means that a system of witness information is less attractive, as the trustworthiness of witnesses comes into play. Only when the group of witnesses is known and trusted or when the number of witnesses is extremely large can a witness information system be used for high-risk transactions. A direct information system will only work when there is enough information available. Initial or externally specific high-risk transactions are not suited for a direct information system. A certification system is more suited for high-risk transactions, especially initial transactions, but it is dependant on the trustworthiness of the certification and thus on the quality of the standardisation, certification and revocation procedures.

5.3 Conclusions

This chapter focussed on the question whether transactions can be classified in such a way that a choice can be made between different types of trust (systems). An attempt was done to use Williamson's model of efficient governance for this purpose. This seems a successful route and further research is needed to deepen the understanding of the relation between trust systems and transaction characteristics. In the next chapter a description is given of the validation of these findings.

6 Validation

In this chapter an attempt is done to validate the research. The validation of this research is difficult due to two reasons. The exploratory nature of this research causes various difficulties. Normally one would apply a framework in practice, or in a reference case, for validation. In this case it was decided to validate the reasoning that led to the conclusion. The goal was set to validate the 'internal validity' of this research, by asking "to what degree [the] inferences are correct, and whether or not rival explanations are possible" (Thiétart, 2001, p. 207). The validation does not concern the full research. The concepts in chapter 5 are of an explorative nature and are not validated.

In the next paragraph (6.1) the setup of the validation is described. Thereafter in 6.2 the inferences to be validated are described, followed in 6.3 by the results. In paragraph 6.4 the conclusions of the validation process are presented.

6.1 Validation setup

The validation was done using a validation workshop with a panel of experts on the topic of trust. The first member of the panel was world-renowned scholar on the topic of trust Prof. B. Nooteboom. The second member was Prof. J. Groenewegen, a scholar on the topic of institutional economics. The last member was Gert-Jan Nickolson, an IT-security specialist. During the workshop 11 statements were put up for open discussion. For each of these statements the participants were asked to give their comments and opinion, followed by a group discussion. Using this technique all statements have been discussed thoroughly, leading to sound conclusions. In the next paragraph the 11 statements are presented.

6.2 Statements to be validated

The goal of the workshop was to test the reasoning within this research. Eleven crucial choices were identified and these were put up for validation. These were:

1. From the literature the combination of the following two definitions are considered appropriate:

- "a psychological state comprising the intention to accept vulnerability based upon positive expectation of the [..] behaviour of another" (Rousseau, 1998, p. 395)

- "Trust is taken here as a four-place predicate: the trustor (1) trusts a trustee (2) in one or more aspects of behaviour (3), under certain circumstances (4)" (Nooteboom, 2005, p. 66)

2. From the literature we have discarded the following definitions (sample only):

- Positive expectations regarding the other in a risky situation. (Das & Teng, 2001)

- Trust [..] is a particular level of the *subjective probability* with which an agent assesses that another agent or group of agents will perform a particular action, both before he can monitor such action (or independently of his capacity ever to be able to monitor it) and in a context in which it affects his own action

- Trust is the expectation that arises within a community of regular, honest, and cooperative behaviour, based on commonly shared norms, on the part of other members of that community (Fukuyama, 1996, p.26)

3. Trust is essentially derived from three dimensions:
- Institutions-based trust
  - Trust gained from political or economic systems or formal institutions
- Process-based trust
  - Trust gained from past or expected exchange such as in reputation or gift-exchange.
- Characteristics-based trust
  - Trust tied to person, depending on characteristics such as family background or ethnicity

4. For our purpose of business to business transactions, I like to challenge the appropriateness/necessity of including:
- Characteristics-based trust
  - Trust tied to person, depending on characteristics such as family background or ethnicity

5. With respect to the Trustee there are three dimensions of trust can be distinguished:
- Intention
  - Is the Trustee intending to perform the requested transaction?
- Competence
  - Is the Trustee capable of performing the requested transaction?
- Predictability
  - Is the behaviour of the Trustee predictable?

6. For our purpose of business to business transactions, I like to challenge the appropriateness/necessity of including:
- Predictability
  - Is the behaviour of the Trustee predictable?
- Rationale:
  - Based on the level of trust in the competence and intentions of a Trustee one can 'predict' his/her future behaviour. One does not trust in a Trustee's predictability.

7. In transitioning from theory to practice, I would argue that:
- Trust in its applicability to transactions in the 'physical' world can be transposed to the 'online' world
- This transposition does not require a transformation of the concept

8. In transitioning from Theory to Technological Solution, I would argue that:
- Institutions-based trust
  - Trust gained from political or economic systems or formal institutions

- Can be operationalised to Certificate-based trust in an online environment

9. In transitioning from Theory to Technological Solution, I would argue that:
- Process-based trust
    - Trust gained from past or expected exchange such as in reputation or gift-exchange.
- Can be operationalised as Reputation in an online environment

10. I would argue that:
- A mode of trust can be chosen

Similarly to the mode of organisation in TCE
- Based on the determinants: Frequency, Specificity and Uncertainty

11. I propose the following links between determinants and modes of trust:

Higher Frequency
- Reputation more precise
- Certification System cheaper

Higher Specificity
- Reputation less precise
- Value of trust becomes more personal

Higher Uncertainty
- Higher levels of trust needed
- Wish for institutionally grounded trust

6.3   Results of the validation workshop

The workshop was a success and every statement got its share of comments. Most statements were accepted, but comments which needed follow-up were given on statements 3, 5, 7, 8 en 11.

Statement 3 concerns the three foundations of trust as defined by Zucker. The consensus in the group was that Zucker did not properly demarcate the three foundations and thus some overlap exists between the three. Later in the workshop, when discussing statements 8 and 9, it was concluded that in this project the three foundations are taken very strict and that statements 8 and 9 mitigated the problems with statement 3.

Statement 5 concerns the three dimensions of trust. The comment here was that there are two types of intentions. There are the 'dedicated intentions' deliberately behaving opportunistically and wrong intentions due to a lack of commitment to the transaction. It was advised to investigate whether this division should be part of a decision framework.

Statement 7 concerns the transposing from the offline to the online world. Here a small discussion was held, with the conclusion that the most important difference is the issue of identity. In the digital world identity is different from the offline world. Transposing trust to the online world could only work if the identity could be guaranteed.

Statement 8 concerns the transposition from institutions-based trust to certificate-based trust. It was generally agreed that this was a correct

transposition and it mitigates problems with statement 3. It was however made clear that proper institutions were needed to support the certification and that this should at least include a feedback system, where a complaint procedure is available and there is room for an evolving certification.

Statement 10 and 11 concern the use of Williamsons TCE-determinants as a tool to choose a trust system. This step was seen as surprising, but charming and correct. One remark was that there is a difference between internal and external frequency. A transaction can be very rare for one transaction partner, but very common in the market place. This difference is significant and should be taken into a decision framework. It was advised to explicitly state that these determinants were used exclusively, for another purpose than they are used in TCE.

In the final discussion it was stressed that even though the foundations by Zucker were shaky at best, the interpretation used in this research was correct. The final step of using Williamson to determine a trust system was deemed surprising, charming and correct.

6.4 Conclusions

A workshop was held to validate the 'internal validity' of this research. This means that the logical steps taken in this report were put up for discussion. The overall conclusion of the validation is that the steps are correct, but a few additions can be made.

The division of the foundations of trust was deemed not the best solution, but the interpretation in this research project and the application in later stages corrected the issues with the division. Other recommendations were made to help improve the steps towards the framework and therewith improve the research.

7 Conclusions and Recommendations

This research was performed to take steps towards a design framework for using trust in electronic business-to-business transactions. In this chapter results of the research are presented and the research questions are answered. Thereafter recommendations are done for future work on this topic.

7.1 Conclusions

This research was conducted to find a way to use trust in online transactions. It started with the idea that trust is an important factor in reducing transaction costs and the fact that trust is not available in online business-to-business transactions. To enable trust in online transactions trust systems are needed. The main research question in this research was as follows.

Which framework can be used to decide upon the foundation of trust to use in a given eBusiness environment?

This research question was answered using a series of sub-questions. The answer is that a framework can be build using Zucker's three foundations of trust and Williamson's model of efficient governance. More research is needed to shape the framework, but the first steps are taken.

One of the major issues in this research was the enormous complexity of the concept of trust. It was found that trust has many meanings, but ultimately these meanings converge in a set of definitions. Trust was found in this research to be "a psychological state comprising the intention to accept vulnerability based upon positive expectation of the [..] behaviour of another" (Rousseau, 1998, p. 395). Trust is also "a four-place predicate: the trustor (1) trusts a trustee (2) in one or more aspects of behaviour (3), under certain circumstances (4)" (Nooteboom, 2005, p. 66). These two combined give a good overview of the meaning of trust.

Trust is a part of a transaction that takes place in an environment. Williamson divided this environment in four layers. The three foundations of trust that were found fit into these four layers.
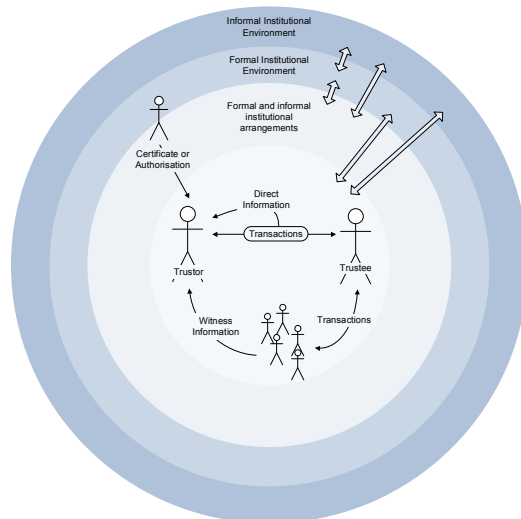
Figure 14: Process of trust in an eBusiness environment

These foundations where Zucker's *Characteristics*, *Institutions* and *Process* (2.4). The fact that they fit into the layer model also means that when designing systems the influence of the other layers should be accounted for. The basic aspects of behaviour one can trust in are *intentions* and *competence* (2.3). It was found that in a business-to-business environment trust based on characteristics is

not used. Institutions-based trust was operationalised as a certification scheme and process-based trust was operationalised as a reputation-system.

This led to three distinct trust systems, with their own benefits. There is the *direct information system*, which is based solely on private experiences with other actors. Then there is the *witness information system*, which is based on information from other actors who have been involved in the same or similar transactions. Lastly there is the *certificate-based system*, where a trusted third party certifies transaction partners.

For each of these three systems technical solutions are available. The difficulty is when to apply each of these systems. To be able to make choices it is necessary to be able to categorise transactions. Therefore a well-known categorisation scheme for transactions was taken from Williamsons Transaction Cost Economics Theory. Normally this categorisation scheme is used to decide on governance mechanisms for transactions, but it was found that applying it for deciding on trust systems was a viable option.

The steps in this research were validated using a validation workshop. The steps were found to be valid, with the inclusion of several recommendations. There has not been a follow-up validation after applying the recommendations.

7.1.1 Relevance

The research in this project has both scientific and practical relevance. The most important contribution is the insight into the requirements of a digital trust system for business-to-business transactions.

The idea that there are three different trust systems, which are solidly grounded in economical theory, supports the scholars who are designing such systems. It gives them a frame of reference to design their systems.

The steps towards a design framework, and especially using Willianson's model of efficient governance in this context, are new in the scientific world. More research is needed to give it a more definite shape.

Users who want to start designing a trust system for their transaction right now can use the notions in this report. It gives them a frame of reference and a set of guidelines towards a preferred trust system.

7.2 Recommendations

There are three recommendations for the scientific community.

1. In Figure 10: Trust in the environmentFigure 10 in chapter 3 an integrative overview of trust in a transaction is given. In the technical research community focus should be shifted from individual trust algorithms towards an integrative framework. This framework should support the three distinct trust systems and support them using both algorithms and an architecture. The community does not need yet another theoretical algorithm, but it needs a system that can be applied in practice.

2. The most innovative, but also the most complex part of the framework is the use of Williamsons determinants for the purpose of choosing a trust system. In this project a first proposal is done, but more research is needed to support this proposal and strengthen the links.

3. Figure 10 also provides countless possibilities to further study trust and its dependencies on the environment. More insight into the workings of this seemingly simple model would provide the means for new steps in the development of the framework proposed here.

8 Reflection

The original goal of this research project was to create a design framework for the use of trust in eBusiness environments. This framework would provide a process to come to a trust system design, providing the user of the framework with decisions and the means to make those decisions. This goal turned out to be overly ambitious. The concept of trust is very complex and there were many steps to take before a framework could be build. The research does provide valuable new insights and ideas and can certainly be used as a basis for further research. On several points in the report great possibilities are just around the corner.

Figure 10 in chapter 3 is such a simple model, but if you dive into it, there is so much interesting material to be studied. A complete thesis could be written just on that figure and what it means for the concept of trust and the consequences when you want to apply trust in a digital world. The way it worked out in this report is just a phantom of what is possible there. The same counts for the use of Williamson's transaction characteristics as a decision model for trust systems. This is new; it has not been done before. If one would invest more time in understanding those relationships it could really work out to be a great decision model. But let's not forget Williamson has received a Nobel Prize for his application of the model to the governance of businesses. Who could top that in a Master thesis?

The scope of the research was big. At some point in time the decision could have been made to narrow down the scope. This would have given the opportunity to dive deeper into a number of the subjects. I have decided otherwise and held on to the scope. This has serious implications on the depth of the work. Was it a wise decision? Maybe. Maybe not. The decision was made and this report is the result.

So this report is just the proverbial tip of the iceberg. At several points it is a bit of a rough diamond, waiting to be polished. Some points feel like shortcuts or giant leaps. Others feel like they just miss the sharpness. Maybe, one day, we will be able to see the diamond shine.

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Appendix A: Literature Review on Trust

Author	Definition	Forms	Foundations	Functions
Bachmann (2001)	No clear definition.	N/A	Personal Trust Systems Trust	Enables the existence of "hybrid" forms of cooperation, such as strategic alliances and organizational networks
Camp, Nissenbaum & McGrath (2002)	Uses Colemans (1990) definition : 1. If the person in whom trust is placed (trustee) is trustworthy, then the trustor will be better off than if he or she had not trusted. Conversely, if the trustee is not trustworthy, then the trustor will be worse off than if he or she had not trusted. 2. Trust is an action that involves the voluntary placement of resources (physical, financial, intellectual, or temporal) at the disposal of tnhe trustee with no real commitment from the trustee. 3. A time lag exists between the extension of trust and the result of the trusting behavior.	Intention & Competence trust	Reputation	Allowing actions that are otherwise not possible
Das & Teng (2001)	Positive expectations regarding the other in a risky situation.	Goodwill and Competence Trust	N/A	Reduce (perceived) Relational and Performance Risk
Dirks & Ferrin (2001)	Rousseau et al. (1998, p. 395): a psychological state comprising the intention	Intentional trust Behavioral trust	N/A	Higher levels of trust are expected to result

Source	Definition			
	to accept vulnerability based upon positive expectations of the intentions or behavior of another.			in more positive attitudes, higher levels of cooperation and other forms of workplace behavior, and superior levels of performance
Fukuyama (1995)	Trust is the expectation that arises within a community of regular, honest, and cooperative behavior, based on commonly shared norms, on the part of other members of that community (p.26)	Honesty, regularity and cooperativeness	Systems trust	Enables Cooperation and lowers transaction costs.
Gambetta (1988a)	Trust (or, symmetrically, distrust) is a particular level of the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action, both *before* he can monitor such action (or independently of his capacity ever to be able to monitor it) *and* in a context in which it affects *his own action* [...].	Predictability of actions	System trust Reputation	Enables cooperation between organizations
Grey & Garsten (2001)	To say that someone is trustworthy is to say that they will exercise their autonomy in ways which are deemed to be responsible. This implies that whilst exercising choice, individuals in organizations will be rendered relatively predictable in what they do, in fact, choose. We call this relative predictability trustworthiness, and its expectation, trust. (p. 231)	Predictability of behavior	Personal and system trust	Enables new forms of control in relationships
Hosmer (1995)	The expectation by one person, group, or firm of ethically justifiable behavior – that is,	Intentional trust, trust in the	N/A	Improve cooperation between trusting

Reference	Definition			
	morally correct decisions and actions based upon ethical principles of analysis – on the part of the other person, group, or firm in a joint endeavor or economic exchange (p. 399)	ethicality of behavior		parties.
Knights, Noble, Vurdubakis, & Willmott (2001)	N/A	N/A	Interpersonal Institution-based	Plenty, quoted from other sources
Luhmann (1988)	Trust is a solution for specific problems of risk. You can gain an advantage by trusting, which you could not receive otherwise.	N/A	Systems trust	Trust mitigates risk
Maguire, Phillips, & Hardy, 2001 (2001)	The expectation of some predictable pattern in the behaviour of others.	Predictability	Calculus-based Knowledge-based Identification-based trust	Trust makes the trustee predictable.
Mayer (1995)	The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important tot the trustor, irrespective of the ability to monitor or control that other party (p. 712)	Ability Benevolence Integrity	Process-based	Not mentioned
McKnight, Larry & Norman (1998)	One believes in, and is willing to depend on, another party.	Benevolence Competence Honesty Predictability	Institutions-based trust Personality-based trust Cognition-based trust	N/A
Nooteboom (2002)	An expectation that things or people will not fail us, or the neglect of awareness of the	Behavioural	Zucker's:	Trust is a means to deal with uncertainty.

	Definition			Benefits
	possibility of failure, even if there are perceived opportunities and incentives for such failure.	Material Competence Intentional Conditional Exemplar Informational Trust	Institutions-Process-based trust Characteristics based trust	Enables relationships Reduces transaction costs
Nooteboom (2005)	the trustor (1) trusts a trustee (2) in one or more aspects of behaviour (3), under certain circumstances (4).	Competence Intentional Trust	Zucker's definitions: Institutions Process Characteristics based trust	Not explicitly mentioned.
Ratnasingham (1998)	the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the agility to monitor or control that other party	N/A	Deterrence-based Knowledge-based Identification-based	A number of efficiency benefits that follow from trust in cooperative relationships include being. Trust has been reported to reduce transaction costs as trust increases the confidence and security in a relationship and promotes open and substantive and influential information

Ratnasingham (2001)	A *rational* (or objective) view which is based on an economic perspective emphasizing the confidence in the predictability of one's expectations. [...] A *relational* (or subjective) view which is based on a social perspective emphasizing confidence in another trading partner's goodwill. (pp. 36-37)	Competence Predictability Goodwil	Institutionalized processes-based trust Incentive-based trust Relationship-based trust	Direct – economic benefits Derived from efficiencies of ecommerce technologies and trading partner competence Relationship related benefits derived from consistent negative trading partner predictability trust Strategic – symbolic benefits exchange.
Reed (2001)	A particular form of social relation based on a backdrop of generalized attitudes and predispositions in which social actors engage in reciprocal interactions based on mutual rights and obligations (p. 217)	Behavior according to attitudes and normative cultural rules	Generalized attitudes and predispositions Normative/Cultural	Enables social relationships
Shapiro (1987)	A social relationship in which principals – for whatever reason or state of mind – invest resources, authority, or responsibility in another to act on their behalf for some uncertain future return.	"Predictability"	Impersonal Trust	Permits complex developments in social organization.
Sydow (1998)	The confidence of an organization in the reliability of other organizations, regarding a given set of outcomes or events.	Reliability Competence Intentions	Personal Trust System Trust	Alternative control mechanism in interorganizational relations Enhance allocative

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Williamson (1993)	The confident expectation of benign intentions by another agent. Trust is inherently incalculative.	Passion	Personal trust According to Williamson all other types of trust should not be called trust.	efficiency Reduce the costs of interorganizational transactions. None in economic transactions
Woolthuis, Hillebrand & Nooteboom (2005)	Definitions by Nooteboom.	Competence Intentional Trust	Process-based	Mitigates relational risk
Zucker (1986)	"A set of expectations shared by all those involved in an exchange" (p.54)	Background expectations Constitutive Expectations	Process-based Characteristic-based Institutional-based	Lowers transaction costs Efficient form of control

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