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FACTORS OF TRUST THAT INFLUENCE TRUSTWORTHINESS IN PEER-TO-PEER (P2P) BASED E-COMMERCE

Farookh Khadeer Hussain¹, Elizabeth Chang¹
School of Information Systems, Curtin University of Technology
GPO Box U1987, Perth WA 6845, Australia
hussainf@cbs.curtin.edu.au, change@cbs.curtin.edu.au

Tharam Dillon²
Faculty of IT, University of Technology, Sydney
Broadway, Sydney NSW 2007, Australia
tharam@it.uts.edu.au

ABSTRACT

Peer-to-Peer Systems are becoming popular. They are widely regarded as the next-generation of the Internet. As a result, electronic commerce will be carried out over the peer-to-peer systems in the future rather than in a client-server environment. These Peer-to-Peer (P2P) systems suffer from innumerable problems. Trust between two interacting peers involved in an electronic transaction is one of them. In this paper, we propose the factors that can influence the trustworthiness assigned to the trusted peer. Furthermore we catalogue these factors into three classes and discuss the relationship between these factors.

Keywords: Trust, Factors, Trusting Peer, Trusted Peer

CLIENT-SERVER AND P2P COMMUNICATION

The advent of the internet and its subsequent ubiquitous use had a huge impact on the way transactions were carried out. Transactions before the arrival of internet were carried out in a face-to-face scenario. Now, these transactions could be carried out over the internet. This later came to be known as electronic commerce, which we feel in simple terms means 'commerce mediated through electronic means'.

Electronic commerce was typically carried in a client-server environment. In client-server environment, there are central computer/s, which hosts and perform almost all the tasks. These central computers are called Servers. The clients usually provide just an interface to the tasks, performed by the servers. All the processing is usually carried out at the server. The servers usually houses the data needed by the client.

For an extended duration of time, after the introduction of the internet to the advent of P2P systems in the form of Napster, this was the way the electronic transactions were carried out over the internet. P2P systems, however, changed the whole scenario. The main difference between P2P systems and the client-server environment is that they transfer the control from the servers back to the clients. They resemble the early forms of internet in many ways and are regarded as the next generation of the internet.

In this paper, we propose factors that are pivotal for the trusting peer in determining whether to trust the trusted peer. Additionally, we catalogue these factors into three clusters each of which comprises factors that directly or indirectly make the trusting

peer trust the trusted peer. We review related work in the factors of trust in client-server e-commerce and discuss the motivation behind our work.

FACTORS OF TRUST IN CLIENT-SERVER E-COMMERCE

Egger [1, 4, 7, 8, 9], proposed set of factors which, if given due importance while designing an interface of a website (or Human-Computer Interaction), can induce trust in the human users of the websites. These factors can communicate trust to the human users [1, 4, 7, 8, 9]. Egger[1, 4, 7, 8, 9] takes a bigger view and considers how factors like the usability of the website, the way content is organized, how security and privacy issues are addressed by the website, can communicate trust to the human users of these websites. The factors proposed by Egger are applicable for B2C e-commerce, where the consumer (usually the client) interacts with the service providers through websites. We feel that the factors proposed by him are applicable primarily to B2C e-commerce and not to P2P e-commerce.

Kim and Moon [5] investigated which graphic design elements in a website can communicate trust to the human users. They, however, do not investigate how the content and the usability of the website can assist in communicating trust to the users. Moreover, they have a much narrower scope than Egger because they claimed that these trust-inducing features were applicable to only the Korean population.

Our domain and motivation is totally different from the above mentioned approaches, which focus on B2C communications and the factors, if given due importance while making websites, that communicate trust to the human users. We focus on peer-to-peer communications and we examine the factors which influence the trusting peer in deciding whether to trust the 'trusted peer. Additionally, we examine the psychological factors that influence the trusting peer. For further discussion throughout this paper we make use of the terms *trusted peer* [3] and *trusting peer* [3]. The trusting peer has to make a decision whether to trust the trusted peer for a given interaction.

FACTORS OF TRUST IN PEER-TO-PEER E-COMMERCE

In this section, we present the factors that can communicate trust to the trusting peer in peer-to-peer e-commerce. We catalogued these factors into three classes, namely:

1. Pre-interaction Factors
2. Reputation Factors
3. Personal Interaction Factors

These catalogues, in turn, consist of other factors. In the following subsections, we define and provide examples of the factors in each catalogue.

1. Pre-interaction Factors

We define Pre-interaction Factors as '*those factors which can influence the trusting peer, whether to trust the trusted peer, before any interaction between the trusting peer and the trusted peer takes place*'. We identify the following three factors in this catalogue:

- i. Psychological nature of the trusting peer
- ii. Attitude of the trusting peer towards P2P e-commerce
- iii. Previous interactions with the trusted peer

We now explain each of these factors and provide examples.

i. (Catalogue 1) - Psychological Nature of the Trusting Peer

We believe that the psychological nature of the trusting peer is a very important factor that influences decisions as to whether they should trust the 'trusted' peer or not. Persons with '**Sensing**' preference have a tendency to rely on facts and experience [10, 11]. On the contrary, persons with '**Intuition**' preference have a tendency to rely more on possibilities and taking risks [10, 11]. We believe that people with sensing preference will not trust any person with whom they did not have any previous interaction. Conversely, we believe that people with intuition preference may trust a person with whom they have not had any previous interactions. Depending on whether the trusting peer has sensing or intuition preference, this preference will influence its decision to trust a given trusted peer with or without detailed information collection of the trustworthiness of the trusted peer.

Persons with '**Thinking**' preference have a tendency to analyze things in an objective and logical fashion with little or no regard for personal values, before they reach or take a decision [10, 11]. Persons with '**Feeling**' preference place primary importance on personal values, before reaching a decision [10, 11]. We believe that if the trusting peer has a thinking preference, he/she will pay little or no importance to personal values of the trusted peer, personal feelings with the trusted peer and make an objective and logical decision whether to trust the trusted peer or not. On the other hand, trusting peers who give preference to feeling will place greater importance on his/her personal feelings of the trusted peer and values of the trusted peer while they decide whether to trust the trusted peer.

Depending on the psychological type of the trusting peer, whether he/she gives preference to 'thinking' or 'feeling', will determine whether he/she make the decision through facts or through the personal values of the trusted peer.

ii. (Catalogue 1) - Attitude or Mindset of the Trusting Peer towards Peer-to-Peer E-Commerce

This is another important factor which will have an influence on the trusting peer, in deciding whether it should or should not trust the trusted peer. As we mentioned previously, with the advent of the internet and its subsequent ubiquitous use, all business transactions were carried out over the internet. However, many people were reluctant to use this medium as a means of carrying out transactions due to the inherent risks involved in electronic business. Many people regarded it as unsafe as they were not totally convinced about how the other entity behaves in things like possessing credit card details, handling privacy issues....

Although technologies like cryptography, digital certificates and various legislation rules have been introduced to mitigate the risk of carrying online transactions, some sections of the populace are still not convinced that the internet is a safe place to carry out transactions, if certain defensive measures are followed. This is the general attitude of the entity towards electronic commerce. An example of such a defensive measure is the verification of the identity of the website with the help of digital certificates before carrying out an electronic transaction.

In peer-to-peer communication, the problem is graver as compared to client-server communication. In client-server communication much of the security measures taken to ensure that the client-server based e-commerce is a safe place to carry out transactions rely on *Trusted Certification Authorities*. In P2P communication, on the other hand, there can be no central authority due to its decentralized nature. Hence, much of the security measures used in client-server communication that can induce trust in consumers cannot be used in P2P communication.

A lot depends on the attitude and mindset of the trusting peer towards the P2P e-commerce. Peer-to-peer e-commerce has far less security guarantees and far more risks involved compared to client-server based e-commerce.

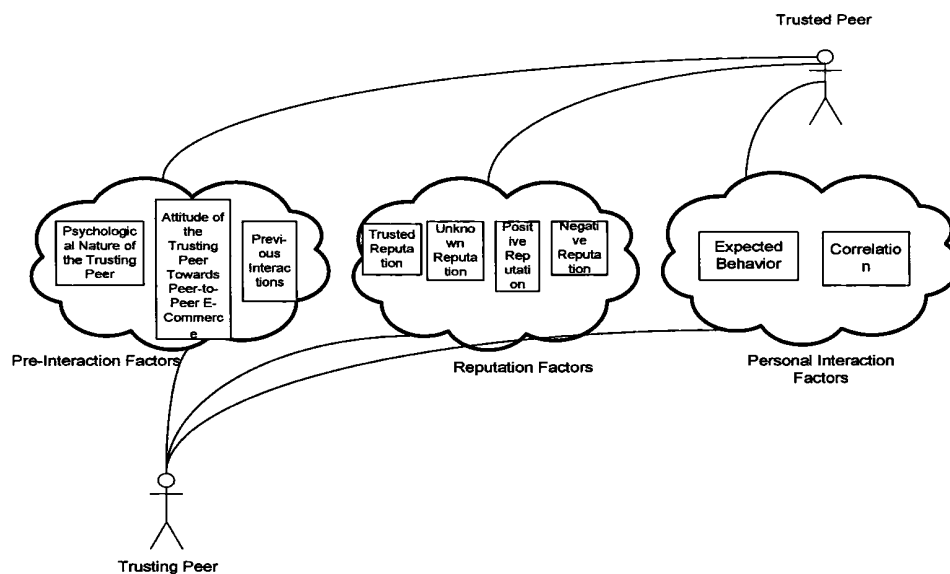


Figure1: Overview of the Factors of Trust in P2P E-Commerce

iii. (Catalogue 1) - Previous Interactions

The outcome of previous transactions between the trusting peer and the trusted peer will have a major bearing on the decision whether to trust the trusted peer again. Depending on the outcome of the previous transaction, the trusting peer will be more confident in deciding whether to trust the trusted peer or not. If the outcomes of the previous transactions are positive then its trust in the trusted peer will grow, and the trusting peer is most likely to trust the trusted peer in future transactions. On the contrary, if the outcome of the previous transaction was negative, this will have a negative impact on the perceived trustworthiness of the trusted peer by the trusting peer.

The above mentioned three factors, namely the *psychological nature of the trusting peer*, *attitude of the trusting peer towards P2P e-commerce* and *previous interactions* have an affect on the trusting peer in determining whether to trust another peer or not, before any interaction with the trusted peer take place. Hence, we have collectively named these factors as **Pre-interaction Factors**.

2. Reputation Factors

As we mentioned previously in P2P communications, there is no central authority to enforce trust-inducing mechanisms like in the client-server environment. As a result, the trusting peer, in order to decide whether to trust the trusted peer, asks other accessible peers about the trustworthiness of the intended peer. These other peers communicate an indication of the trustworthiness of the trusted peer. This method of asking the other peers in the network about the trustworthiness of the trusted peer can help the trusting peer in deciding whether it should trust the trusted peer. We call this gathered information on the trustworthiness of the trusted peer its 'Reputation'. We define reputation factors '*as those factors pertaining to the reputation of the trusted peer and can influence the trusting peer in deciding whether to trust the other peer or not*'. We identify four major factors pertaining to the reputation of the trusted peer, which can influence the decision of the trusting peer:

- iv. Trusted Reputation
- v. Unknown Reputation
- vi. Positive Reputation
- vii. Negative Reputation

iv. (Catalogue 2) - Trusted Reputation, and

v. (Catalogue 2) – Unknown Reputation

As mentioned previously, in order to find the trustworthiness' of a peer, the trusting peer asks other accessible peers about the trustworthiness of the trusted peer. Any peer present in the network can respond to the trusting peer's request for information regarding the trustworthiness of the trusted peer. Malicious peers may reply with a deceptive trust value; increased or decreased trust value for the trusted peer. Malicious peers may respond with a trust value even if the trusted peer has not had an interaction with them.

In order to counter this problem, we propose that the trusting peer, classify the reputation that it acquires from contemporary peers in the network into three broad groups namely:

- Reputation obtained from peers who it trusts to give accurate recommendations. For discussion purposes we term them *trusted or trustworthy peers*.
- Reputation obtained from peers who it does not trust to give accurate recommendations. We term them as *un-trusted or untrustworthy peers*.
- Reputation obtained from peers with whom it does not have an experience of soliciting reputations. We term them *unknown peers*.

The trusting peer, over a period of time, can come to know which peers report truthful and accurate trustworthiness values and which peers give misleading, deceitful trust values. We propose that Reputation obtained from trustworthy peers be called **Trustworthy Reputation** and that obtained from untrustworthy peers be called **Untrustworthy Reputation**. Additionally, the trusting peer may receive trustworthiness' values from other peers with whom it has no previous experience of soliciting recommendations and hence their recommendations cannot be classified as either trustworthy reputation or untrustworthy reputation. We propose that such a reputation be known as an **Unknown Reputation**. Unlike the untrustworthy reputation which is fraudulent, unknown reputation can be fraudulent or truthful.

We propose that when the trusting peer receives the reputation of the trusted peer from other peers in the network, it should disregard the untrustworthy reputation. It should put more credence on trustworthy reputation and some weight on the unknown reputation (as it is not sure whether this reputation is trusted or not). We believe that the two main factors that aid the trusting peer in deciding whether it should trust the trusted peer or, in other words, the factors which induce trust in the trusting peer are trustworthy reputation and unknown reputation, since the trusting peer, takes these two into account before deciding whether to trust the trusted peer or not. It disregards the un-trusted reputation as fraudulent.

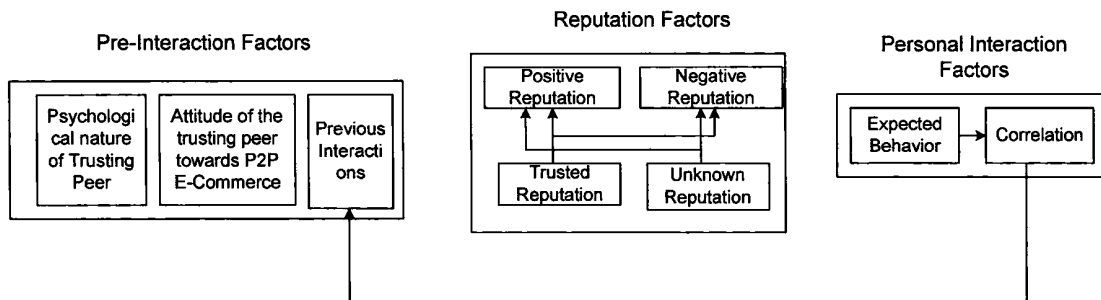


Figure 2: Relationship between the Individual Catalogues and Individual Factors

vi. (Catalogue 2) - Positive Reputation, and

vii. (Catalogue 2) – Negative Reputation

The trustworthy peers and the unknown peers can give a positive or negative recommendation about the trusted peer. These reputation values of the trusted peer communicated by the trustworthy peers and the untrustworthy peers can influence the trusting peer to a great extent, in deciding whether it should trust the trusted peer or not.

If the trusting peer receives a significant positive reputation from trustworthy peers and new (unknown) peers, it can have a great affect while deciding to trust the trusted peer. On the contrary, if it received significant negative reputation from the trustworthy peers and unknown peers, this can communicate to the trusting peer not to trust the trusted peer. Hence, both positive and negative reputation of the trusted peer obtained from the trustworthy and unknown peers can aid the trusting peer in deciding whether it should trust the trusted peer. Since the trusting peer disregards the reputation of the trusted peer, obtained from un-trustworthy peers, the reputation obtained from untrustworthy sources is an insignificant factor when deciding whether to trust.

As an example, let us consider the Gnutella Peer-to-Peer File Sharing Application. Let us assume that Peer A, Peer B, Peer C, Peer D , Peer E, Peer F and Peer G are peers in the Gnutella P2P File Sharing Application. In this example, we consider two transactions with Peer A as the trusting peer.

Transaction1:

Peer A has previously had a transaction with Peer F. Before carrying out a transaction with Peer F, Peer A had asked about the reputation of Peer F from Peer B and Peer G. On subsequent interaction with the Peer F, let us assume that Peer A found that the reputation value communicated by Peer B is correct and that communicated by Peer G is untrue. Additionally, Peer A has had no previous experience of soliciting recommendations from Peer C, Peer D and Peer E.

Transaction2:

Peer A wants a file by the name 'Peer-to-Peer.doc' and additionally wants it to be uploaded to him/her at 300 KB/s. Peer A broadcasts a query to every one in the network. Peer D responds to the query stating that it has the file and can upload it to Peer A at 350 KB/s. Peer A asks all the other peers in the network about the trustworthiness of Peer D in the *context* of sharing a file. Peer B, Peer C, Peer E, Peer F and Peer G respond with a reputation value for Peer D.

Peer A, on the basis of previous experience with Peer G, disregards the reputation value communicated by Peer G about Peer D. Additionally, on the basis of his previous interaction in the *context* of soliciting recommendations from Peer B, he can suppose that the reputation value communicated by Peer B will be correct and not fraudulent like Peer G.

Peer A, while deciding the trustworthiness value of Peer D, can lay more emphasis on the trustworthiness value communicated by Peer B and can ignore the reputation value communicated by Peer G. He can lay small emphasis on the trustworthiness value of Peer D that obtained from Peer F, Peer C and Peer E as it does not know if they are correct or not.

Hence, we observe that the reputation of the trusted peer obtained from unknown peers (Peer F, Peer C and Peer E) and the reputation obtained from trusted peers (Peer B) influence the trusting peer, while deciding whether to trust the trusted peer.

The unknown peers (Peer F, Peer C and Peer E) and the trusted peers (Peer B) can either convey a good reputation about the trusted peer or a bad reputation about the trusted peer. As explained previously, these good/bad recommendations about the trusted peer can help the Peer A to decide whether to trust Peer D. A good recommendation about Peer D communicated by the trusted and unknown peers, can strongly indicate to Peer A that Peer D is trustworthy in a given specific context. A negative recommendation communicated by the trusted and unknown peers, can strongly indicate to Peer A that Peer D is untrustworthy in that given specific context.

3. Personal Interaction Factors

We define Personal Interaction Factors '*as those factors which help the trusting peer to associate a trustworthiness value to the trusted peer based on its personal interaction with the trusted peer*'. Based on these personal interaction factors, the trusting peer can assigning a specific trust value to the trusted peer and decide whether to trust the trusted peer in the future.

We identify two main factors in this catalogue. They are:

viii. Expected Behavior

ix. Correlation

viii. (Catalogue 3) - Expected Behavior

We define the expected behavior of the trusted peer as *'the mutually anticipated conduct of the trusted peer prior to its interaction with the trusting peer'*.

The trusting peer, before laying its trust on the trusted peer in a given context, has an impression or an idea of how the trusted peer will behave for that context. In peer-to-peer e-commerce this impression is communicated by the trusted peer and is mutually agreed. The trusting peer uses this impression of the trusted peer as a baseline when deciding if the trusted peer has acted in a trustworthy way. It uses this impression as a checklist or guideline while associating a particular trustworthiness value to the trusted peer.

ix. (Catalogue 3) - Correlation

We define correlation as *'the degree of parallelism between the expected demeanor of the trusted peer and actual demeanor of the trusted peer during interaction'*.

Correlation refers to the degree of correspondence between the following two factors:

- The impression the trusting peer holds of the trusted peer for a given context
- The outcome of interaction between the trusting peer and the trusted peer for that particular context

The greater the correlation between these two factors, the higher will be the trustworthiness value assigned to the trusted peer by the trusting peer and vice versa. Strong correlation between the above mentioned factors indicates that the trusted peer met the impression held by the trusting peer, in that context. On the other hand, a weak correlation indicates that the trusted peer failed to meet the impression held by the trusting peer in that context.

We extend the above example about the Gnutella Network in the previous section to show how the above two factors influence the trusting peer while determining the trustworthiness value to assigned to the trusted peer and this trustworthiness value can serve as a guide for the trusting peer in deciding whether to trust the trusted peer in future .

Peer D, as explained in the previous example, replied to Peer A's query stating that it has the file entitled 'Peer-to-Peer.doc' and it can upload it at 350 KB/s. Peer A now expects Peer D to(Expected Behavior):

- Upload the file entitled Peer-to-Peer
- This file will be a Word Document
- Upload the file at 350 KB/s

Peer A uses these factors as a guideline for determining the trustworthiness of Peer D. To assign a particular trustworthiness value to Peer D on the basis of its interaction, Peer A finds out the degree of parallelism between what Peer D claimed (the three factors mentioned above) and the extent to which Peer D fulfilled what it did. If Peer D performed all or almost everything of what it had initially claimed it will get a high trustworthiness value from Peer A. On the contrary, if Peer D did not fulfill a large part of what it had initially claimed, it will get a low trust rating by Peer A.

Hence, we observe that the expected behavior by the trusted peer and the degree of correlation between what the trusting peer expects and what it gets from the trusted peer are significant factors that the trusting peer takes into account while assigning a trustworthiness value to the trusted peer.

We propose the following points about the factors of trust that we have mentioned:

- We have categorized the nine factors into three categories.
- The factors in the first Catalogue (Factors i, ii and iii) are independent.
- The factors in the second catalogue (Factors iv, v, vi and vii) and the third catalogue (Factors viii and ix) are not independent of each other. The ways they are dependent on each other are shown in Figure 2. The way they are dependent are shown by the arrows .
- At any point in time , these factors are pivotal in:
 - Deciding whether to trust the trusted peer
 - Determining trustworthiness of the trusted peer

CONCLUSION

Through detailed studies, we proposed nine factors of trust in Peer-to-Peer E-Commerce and catalogued them into three classes. We found that the existing literature does not present the components of trust that influence trust. Our future work involves showing how trust is built, maintained and destroyed using these factors.

REFERENCES

- [1] Bhiru Shelat, Florian N.Egger, F. 2002, What Makes People Trust Online Gambling Sites?, Available: [http://www.ecommuse.com/research/publications/chi2002.pdf] (10/08/2003).
- [2] BJ Fogg, Hsiang Tsueng., The Elements of Computer Credibility Available:[http://delivery.acm.org/10.1145/310000/303001/p80-fogg.pdf?key1=303001&key2=8303186701&coll=portal&dl=ACM&CFID=16753875&CFTOKEN=3600767](10/10/2003).
- [3] Farookh Khadeer Hussain, Elizabeth Chang, Tharam Dillon 2004, 'State of the Art in Trust in Ad-Hoc Peer-to-Peer (P2P) Networks', in International Conference of Computer Applications, Myanmar.
- [4] Florian N.Egger, Boyd de Groot. 2000, Developing a Model of Trust for Electronic Commerce: An Application to a Permissive Marketing Web Site, Available: [http://www.ecommuse.com/research/publications/WWW9.htm] (20/6/2003).
- [5] Jinwoo Kim, Jae Yun Moon, Emotional Usability of Customer Interfaces, Available: [http://hci.yonsei.ac.kr/non/e02/97-CHI-Emotional_Usability_of_Customer_Interface.pdf] (23/08/2003).
- [6] Myers, S. 2003, Working out your Myers Briggs type, Available: [http://www.teamtechnology.co.uk/tt/t-articl/mb-simpl.htm] (27/12/2003).

- [7] N.Egger, F., "Trust Me, I'm an Online Vendor":Towards a Model of Trust for E-Commere System Design, Available: [http://www.zurich.ibm.com/~mrs/chi2000/contributions/egger.html] (10/09/2003).
- [8] N.Egger, F., Towards a Model of Trust for E-Commerce System Design, Available: [http://www.zurich.ibm.com/~mrs/chi2000/contributions/egger.html] (29/05/2003).
- [9] N.Egger, F. 2003, Deceptive Technologies:Cash, Ethics &HCI, Available: [http://www.ecommuse.com/research/publications/sigchi_bulletin.htm] (23/05/2003).
- [10] Yao-Hua Tan, Walter Thoen. 2000, The Formal Aspects of a Generic Model of Trust for Electronic Commerce, Available: [http://www.computer.org/proceedings/hicss/0493/04936/04936006.pdf] (2003).
- [11] G.Mallach, E. 2000, Decision and Data warehouse Systems, Irwin Mc Graw Hill Companies.