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Trust as a Design Aspect of Context Aware Systems

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Summary / Abstract

The purpose of this article is to show the importance of trust as a design aspect of context aware systems. We use an example of a context aware application, identify user's uncertainties and follow Muir's [1] logic of a trust network to show the relevant trust relations. Based on these results we provide recommendations how these relations can be supported leading to higher trust in the whole application and thus to a higher acceptance of the application. Our exemplary approach shall show developers and designers of such systems how important trust relations can be identified and what design choices can address this relations to enhance the chance of success of the context aware system.

1 Introduction

Trust is a concept widely used in many different research disciplines [2]. Usually the emphasis in research on trust lies on its importance for human relationships were trust is for example considered a "...key to understanding the relationship development process" [3] or "…a glue that holds the relationship together" [4].
Besides its importance for human relationships researchers highlighted that trust is also an essential aspect when investigating the adoption of new technology of all kinds [5], [6] and that further research in this direction is necessary [7], [8]. Despite the need for further insights, some authors have already pointed out that many insights from research on trust in human relationships can be adapted [8] or extended [1] for trust in IT artifacts.
Due to this impact many researchers emphasize the importance of trust building [6], trust support [9] and the identification of factors for the creation of trust [10] for supporting the acceptance and sustainable usage of new IT artifacts.
According to Muir's argumentation, the main reason for trust in IT artifacts being necessary is that humans can hardly gain complete knowledge of the inner structures of such systems [1]. Consequently we would expect the importance of trust to grow with the complexity of IT artifacts.
With the advent of ubiquitous computing, users will soon be confronted with highly complex systems which additionally should disappear and according to Weiser [11] "weave themselves into the fabric of everyday life until they are indistinguishable from it". As a result, users of such systems will nearly have no knowledge of the inner structures at all, leading to the conclusion that trust will be a very important factor for the acceptance of ubiquitous computing.
As a consequence, context aware systems (CAS), as an essential component of ubiquitous computing must be designed in a way that users can develop trust in these systems for being accepted and sustainably used [12].
The aim of this contribution is to discuss the nature of trust in CAS and to provide a first idea of a trust model helping to design such systems. To achieve this, in the remainder of the article we will, provide our general understanding of trust in section 2, discuss the specialties of trust in CAS in section 3 and provide recommendations for the design of trustworthy CAS in section 4. The contribution closes with a conclusion and recommendations for future research in section 5.

2 Trust

Trust is interpreted as being very multifarious [13] [2] thus leading to different definitions, depending on the respective point of view. Nevertheless, Rousseau et al. [14] noted that the different definitions have a common core based upon positive expectations and vulnerability. Our contribution builds upon the often used definition of Mayer et al. [15]: "...trust […] is 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 ability to monitor or control that other party."
Another consequence of the wide-spread use of trust is overlapping categorizations. In order to cluster the different antecedents found in literature in a distinct manner, we followed the interpretation of [13] and [9] using three main categories of trust: dispositional trust, interpersonal trust and system trust. Dispositional trust refers to the general attitude towards trusting other people. This type of trust is seen as being independent of a specific context or party, can vary across societies [16] and is shaped in early child-

hood, and therefore hardly influenceable afterwards [17]. Interpersonal trust refers to trust that one person has directly in another person. This type of trust is party- as well as context-specific. For example, you may trust your mechanic Bob to fix your car, but not to babysit your child. The third type of trust, system trust, refers to trust that is based on perceived properties or structures of an institution or system. This can refer to trust in the monetary system or the internet.

In considering the discussed relations of trust can be established, trust, whether in persons or systems, is not available just from the start and needs a structure and a constant care. This procedure can be described as a trust process. In this context, there are several distinctions in the literature. For example a process with the phases before and after the first interaction [4] or a process with the three phases of building, maintaining/stabilizing and loosing trust [14].

Various authors such as [18] see at the beginning of a transaction a high level of Trust. This initial trust grows, but changes also with the increasing length of the relation. It is based on a relational decision, personal disposition or existing information. The trust must be constantly maintained, so that it remains. The disappointment of the trustor by the trustee leads to a loss of trust.

According to McKnight et al. [18] there are three areas of influence on the trust-building to differentiate: Disposition to Trust (conclusions about the trustworthiness retained by the use of human behavioral characteristics), Cognitive Processes (e.g. categorization processes to assess the perceived trustworthiness) and Institution-Based Trust (existence of structural assets). The three areas of influence have either a direct effect on trusting intention or have an indirect effect concerning the trusting beliefs. Trusting beliefs are characterized by the dimensions Benevolence, Competence, Honesty and Predictability [6]. Perceptions about all for factors can usually be built quickly at the beginning of a relationship and don't need to be created up over the time.

Especially when acting in terms of the familiarity, past information plays a special role, which arise from the own trustee´s experiences [19]. If there is no subjective information available, the trustee must align with the experience and knowledge of third parties. In this case we talk about reputation. Reputation is defined as "a characteristic or attribute ascribed to one person (form, industry, etc.) by another […] operationally this is usually represented as a prediction about likely future behaviour" [20]. It is based on opinions, knowledge and experience of other people about the trustworthiness and competence of a person or institution [20]. In this way the past behavior is used as an indicator of future behavior.

Considering trust in complex systems, like CAS, Muir [1] states that it is like that trust in such systems are best represented by a so called trust network including the different stakeholders, e.g. user, system and developer.

Building upon this theoretical basis in the remainder of this contribution we will consider the function, processes and different stakeholders of trust in CAS.

3 Trust in Context Aware Systems

Each trust situation is always preceded by an element of risk and uncertainty. Luhmann [19] [21] emphasizes this point and argues that trust reduces information complexity and lowers the perceived risk of a transaction. Mayer et al. [15] expect that trust should have a positive influence on risk taking in a relationship because trust is likely to alleviate concerns regarding these types of possible negative consequences. According to this, we will introduce below a case study from previous work [22] [23] to illustrate a context aware system and to drive element of risk by using this system:

Our case study Mobile Event Guide (MEG) can be described as a conceptual example of an event guide realized through mobile technologies. MEG is a context-based mobile application for people visiting large art or other cultural events. It helps users to find their way around large events quickly and in a targeted way. Based on an evaluation of current contextual-data, a preset user profile, preference records, and continually generated visitor statistics/evaluations, this service provides customized information and services, as well as community communication for users across the entire event. In addition to this, local and urban exhibition-limited ratings, votes, and forums are set up. These include individually customized tours as well as listings of the most important attractions, works of art, and current accompanying events within the local vicinity of the user's current location. It is also important to mention that there is no single day like another and the preferences of experts and art novices could differ extremely. Nevertheless it is possible to publish and automatically evaluate rankings about the most attractive works of art and even to create timing-, weather- and visitor-number-based route plans.

Such a local and contextual mobile social software solution is enriched by the voice of the crowd. The mass of visitors acts as a counter balance to the opinion of expert art critics. Indeed, visitors are given a voice and an opportunity to influence the interaction. Recommendations and rankings are aggregated and could be retrieved locally. Besides this daily or weekly cluster results can be retrieved. People can see how people of the same age or people from their own regions have rated the artworks. Also friends and acquaintances can be identified. Information about whether or not they join the event currently and where they are located could be provided. Guidance systems and directions to facilities can be optimized and information can be send in a location-related way. All visitors, however, will only be able to submit a critique when they are actually at the location and have been identified as a visitor. It will be possible to create forums, tips and even new user-generated categories for ratings. Thus the visitors will become part of a local and contextual event.

This example demonstrates many situations in which they exists uncertainties and thus trust plays a significant role. We can identify the following uncertainties:

- Information Quality; Resembles uncertainty towards desired characteristic of the information like accuracy, meaningfulness and timeliness [24]. Information Quality is important for the users of the MEG when they want to visit accompanying events within the local vicinity of their current location. The user would be disappointed if he wants to visit such an event but it has been cancelled and the information was not updated.
- Quality of Context Data; Reflects uncertainty concerning the correctness of the gathered sensory input [12]. Quality of Context Data is important when the users want to view art critics of experts or other visitors exactly for the artwork they are currently looking at. The MEG must ensure that it can capture this context even if several art-works are in the current location.
- Quality of System Generated Solutions; Resem-bles uncertainty towards the quality of the computed solution or recommendation [8]. Quality of System Generated Solutions is important for the users when they decide to use the service for getting a timing-, weather- and visitor-number-based route plans.
- Information Privacy; Reflects uncertainty concerning the ability to control when, how, and to what extent user´s personal information is communicated to others [25]. Information Privacy is important when the MEG uses cur-rent contextual data, a preset user profile and preference records for computing customized information and services. The MEG will have to communicate with other sys-tems to create these information and services and must en-sure that data the user doesn't want to share will not be ac-cessible for other parties.
- System Dependability; Resembles uncertainty towards desired characteristics of the system like reliability and availability [26]. System Dependability is crucial in many situations in the scenario. The user would be disappointed if he is looking at an artwork and want to gather more information, or when he wants to check whether there are any events in his local vicinity but the service is currently out of order.
- Feeling Control; Reflects the feeling of having something under control as a result of our experience forms an important trust factor [27]. Thereby we talk about our own abilities and experiences. It does not depend on the actual existing knowledge and skills, but on our own perception of it.

Based on the identified uncertainties we will now use our theoretical foundation and Muir's [1] logic to create the trust network of our scenario.

The first step is to identify the different parties or stakeholders that are included into the trust network. In our scenario we can identify four groups: The provider of the MEG, the MEG itself, the different event organizers supplying information about local events they are hosting and the users of the MEG. Like Muir [1] we decided to split the users into two "parties" (user 1 and user n) to show that there are also trust relations between the single users. Figure 1 visualizes the trust network of the MEG scenario.

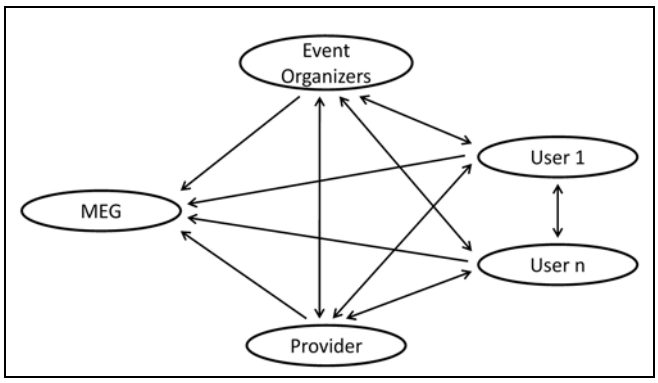

Figure 1 Trust network of the MEG

The next step is to explain some general points concerning the trust network. Firstly it seems obvious that the MEG does not trust any other party of the network because it is a CAS and does not match our definition which focuses on human trust. Secondly it seems quite confusing that every party has a trust relation with all the other parties involved. This effect is caused by a detail in the MEG scenario. We allow the users to submit critiques concerning the different locations. These information are known as user generated content [28] and this detail leads to the complexity of the network.

The last step is to discuss the different relations inside the network. The operator has to trust the MEG, otherwise he would not offer it to its customers because he would risk his reputation. Additionally, due to the user generated content, the operator must trust his users that they provide valuable content for the other users. Finally he needs to trust the locals to provide up-to-date information about the current local events to ensure satisfied customers.

The locals need to trust the MEG that their events are recommended to the target group in the right moment to gain additional visitors. They also need to trust the operator that he commits to the agreed conditions. For example one local event organizer paid some amount for a specific number of recommendations in their target group or all locals agreed with the operator on a "fair" recommendation of the single local events. Finally, like the operator, they need to trust the users of the MEG to provide valuable information for the other users if the same event will be repeated several times during a longer cultural event like the Documenta in Kassel which lasts for 100 days.

The users need to trust the MEG in providing exactly the information they need in a specific situation, otherwise they would not use the system or could not fully enjoy their visit because the MEG requests some of their attention. Additionally they need to trust the operators concerning the selection of appropriate and high quality expert art critics or recommendation of certain events based on their individual preferences and not on monetary factors. They also need to trust the locals to provide accurate and up-to-date information about the events in the vicinity. Additionally, they need to trust each other for being able to make decision based on the provided user generated content.

Last but not least the user also needs the feeling that he has the ability to fully control and correctly use the MEG.
The complexity of the network shows that many different trust relations have to be considered and correctly supported to ensure the success of the whole network and consequently the system. In the next section we will provide recommendations concerning the trustworthy design of CAS.

4 Recommendation for Designing Trustworthy Context Aware Systems

Due to the complexity of our developed trust network we will exemplary address some of the identified trusting relations. Therefore we have to focus on only some which we think are very important for the success of the MEG. Following the user-centered design approach [29] we will target the trusting relations that resemble the end user trust in his own abilities and the other parties of the MEG. Based on this choice we will in the latter discuss the major points concerning the following five trust relations of our trust network:

- user 1 → user 1
- user 1 → user n
- user 1 → MEG
- user 1 → providers
- user 1 → event organizers

We will start discussing how to support the trust of the end user in his own capabilities of using the system (user 1 → user 1). Own/past experiences play a major role to support the identified uncertainties "Feeling of Control" and "System Dependability". A factor, both in building and maintaining the trust exercises the experience of the individual, which the user draws from his own past information. This influence in the form of individual experiences in dealing with the technology or the technical infrastructure enhances user trust in institutions or in own abilities and competences. One measure would be the early involvement of users in the design process. Hermann et al. [30] present in this context with the social technical walkthrough an approach for participatory development of new systems. After the preparatory phase prototypes and process descriptions will be discussed in workshops held in conjunction with future users.
Concerning the support of the trust relation between one end user and the other end users (user 1 → user n) we can use reputation to support the uncertainty "Information Quality". The MEG scenario builds upon the idea that users customized information and services, offerings around large arts and cultural events, are available. These offers are based on current contextual data which are available at all times and regardless of the location. They also are based on the preset user profiles, preferences and user statistics. Thus the information in MEG differ in general information (e.g. user generated content about the history of an art), time-critical information (e.g. user generated evaluation of an ongoing event), and context information (e.g. the queue in front of an exhibition, weather information). The user does not distinguish between the different types of information. So measures must be built to develop user trust in information. Similarly, measures need to be built to prevent trust injurious behavior. This can also deal with the use of past information, but by third parties. The trustworthiness and the quality of the information are generated by a third party. The level of trust can be greatly increased if the positive information rapidly and extensively spread within the network. Reputation is therefore an important indicator. It supports the establishment of trust both through perceived competence and perceived goodwill [9]. There are several ways to promote the communication and visualization of reputation indicators. The identification and the placement of reputation made by specific organizations (e.g. eTrust, Schufa) are a way to provide the perceived competence. Other ways are reputation mechanism to evaluate user and system generated contents. For example methods of peer-rating for direct evaluation or implicit rating-methods, that are based on the popularity of a reputation object (e.g. by the number of links to a person or a contribution or the number of times).
The next point is the end userg trust in the MEG (user 1 → MEG). One important uncertainty which needs to be countered here is the uncertainty towards the quality of system generated solutions. Therefore we need to support the user's belief that the system is trying to generate the best possible solution for him. This can be done by making the process used to generate this solution more open. So the MEG should be able to provide information why he generated exactly this solution in this moment for that user if the user wants to get this information. Additionally the user should have the possibility to choose between different solutions if he thinks that the presented solution is not suitable. The MEG should offer the opportunity to decline a generated solution leading to a new calculation or leading to the presentation of e.g. 3 solutions leaving the final choice to the user himself. Another uncertainty which should be countered here is information privacy. The MEG should provide a detailed and easy-to-use possibility to define which personal information can be seen by the other users and which can only be used by the system to generate the best possible solutions. This could be done using different roles for the single participants of the trust network ensuring that unknown users can e.g. only see pseudonyms instead of one real name but also supporting the opportunity to provide specific information to known users which could be meet e.g. for dinner.
Another important aspect is user trust in the provider of the MEG (user 1 → provider). In our theory section we mentioned that trust in other parties is e.g. based on characteristics like competence and benevolence. The user's perception of the provider's characteristics can be influenced to increase user trust in the provider. An example could be that the user can try the MEG for some hours without obligation. This would increase the perceived benevolence of the provider because the user has the feeling that the provider has the interests of the users in mind. Additionally

this action would increase the perceived competence of the provider because it seems that he is convinced that his service has a very high quality. Otherwise he would not offer this non-binding possibility of testing the MEG.

Last but not least we need to discuss how we can support user trust in the different event organizers (user 1 → event organizer). An important uncertainty in this context is uncertainty towards the quality of the information provided. It would be very disappointing for the user if events he wanted to visit and he basis his route on were cancelled and this information was not available in the MEG. A possibility to counter this uncertainty is to provide information about when the event information were gathered or updated. Information which were provided e.g. today seem much more reliable to the user than event information which have not been updated for e.g. 3 months. Therefore the MEG should provide details about the timeliness of the event information provided to help support the user's decision to plan a visit of that specific event or not. Another possibility is to include an option in the route-planning system which allows the user to exclude local events from the calculation if the provided information is older than e.g. 1 month. This would additionally support user trust in the MEG.

The last example shows that the effect of single design choices can affect multiple trust relations in the network. Vice versa the designer should be aware that there could be effects which help to support one trust relation but at the same time have a negative impact on other trust relations in the network. Therefore we urge to evaluate the single design choices concerning their impact on the different identified trust relations.

5 Conclusions

In this paper we pointed out that trust is an important design aspect of CAS. Firstly we provided our understanding of trust. Then we described why trust is an essential element when designing CAS. Afterwards we identified possible uncertainties to use such applications and created the trust network of the MEG. Thereafter we discussed how important relations of the trust network can be supported to strengthen user trust in the MEG leading to a bigger chance for success of this system. The main aim of this article is to encourage system developers and designers to consider trust as an important design aspect of CAS.

Future research should focus on a more theoretically based choice of specific design aspects. We provided several ideas from theory and practice but for systematically support the different trust relations in high complex and innovative system it seems very promising to identify and check relevant theories to gather completely new theoretically based design ideas that help supporting the success of CAS. Furthermore it could be promising to involve the potential future users early in the design process to get additional ideas and wishes that help to enhance the degree the system meets their requirements.

6 Literature

[1] Muir, B.M.: Trust in automation: Part I. Theoretical issues in the study of trust and human intervention in automated systems. Ergonomics, 1994. 37(11): p. 1905 - 1922.

[2] Ebert, T.A.E.: Facets of Trust in Relationships – A Literature Synthesis of Highly Ranked Trust Articles. Journal of Business Market Management, 2009. 3(1): p. 65-84.

[3] Morgan, R.M. and S.D. Hunt: The Commitment-Trust Theory of Relationship Marketing. Journal of Marketing, 1994. 58(3): p. 20.

[4] Singh, J. and D. Sirdeshmukh: Agency and trust mechanisms in consumer satisfaction and loyalty judgments. Journal of the Academy of Marketing Science, 2000. 28(1): p. 150-167.

[5] Jarvenpaa, S., N. Tractinsky, and M. Vitale: Consumer trust in an Internet store. Information Technology and Management, 2000. 1(1-2): p. 45-71.

[6] Gefen, D., E. Karahanna, and D.W. Straub: Trust and TAM in Online Shopping: An Integrated Model. MIS Quarterly, 2003. 27(1): p. 51-90.

[7] Vance, A., C. Elie-Dit-Cosaque, and D.W. Straub: Examining Trust in Information Technology Artifacts: The Effects of System Quality and Culture. Journal of Management Information Systems, 2008. 24(4): p. 73-100.

[8] Wang, W. and I. Benbasat: Trust in and Adoption of Online Recommendation Agents. Journal of the Association for Information Systems, 2005. 6(3): p. 72-101.

[9] Leimeister, J.M., W. Ebner, and H. Krcmar: Design, Implementation, and Evaluation of Trust-Supporting Components in Virtual Communities for Patients. Journal of Management Information Systems, 2005. 21(4): p. 101-135.

[10] Bart, Y., et al.: Are the Drivers and Role of Online Trust the Same for All Web Sites and Consumers? A Large-Scale Exploratory Empirical Study. Journal of Marketing, 2005. 69(4): p. 133-152.

[11] Weiser, M.: The computer for the 21st century. SIGMOBILE Mob. Comput. Commun. Rev., 1999. 3(3): p. 3-11.

[12] Antifakos, S., et al.: Towards improving trust in context-aware systems by displaying system confidence, in Proceedings of the 7th international conference on Human computer interaction with mobile devices & services. 2005, ACM: Salzburg, Austria. p. 9-14.

[13] Abdul-Rahman, A. and S. Hailes: Supporting Trust in Virtual Communities, in Proceedings of the 33rd HICSS - Volume 6. 2000.

[14] Rousseau, D.M., et al.: Not so different at all: A cross disziplinary view of trust. Academy of Management Review, 1998. 23(3): p. 393-404.

[15] Mayer, R.C., J.H. Davis, and F.D. Schoorman: An In-tegrative Model of Organizational Trust. Academy of Management Review, 1995. 20(3): p. 709-734.

[16] Fukuyama, F., Trust: the social virtues and the creation of prosperity. 1995, New York: The Free Press.

[17] Erikson, E.H.: Identity: Youth and crisis. 1968, New York: W. W. Norton.

[18] McKnight, D.H., L.L. Cummings, and N.L. Chervany: Initial Trust Formation in New Organizational Relati-onships. Academy of Management Review, 1998. 23: p. 473-490.

[19] Luhmann, N.: Trust and power. 1979, Chichester, UK: Wiley.

[20] Wilson, R.B.: Reputation in games and markets, in Game Theoretic Models of Bargaining with incomplete Information, A. Roth, Editor. 1985, Cambridge University Press: Cambridge. p. 27-62.

[21] Luhmann, N.: Vertrauen. 3., durchges. Aufl. ed. 1989, Stuttgart: Enke.

[22] Bohl, O., S. Manouchehri, and U. Winand: Mobile In-formation Systems for the Private Everyday Life. Mo-bile Information Systems, 2007. 3(3-4): p. 135-152.

[23] Bohl, O., S. Manouchehri, and U. Winand: Designing private e- and m-Services. International Journal of Knowledge Management Studies (IJKMS), 2008. 2(1): p. 64-79.

[24] DeLone, W.H. and E.R. McLean: The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. Journal of Management Information Systems, 2003. 19: p. 9-30.

[25] Son, J.-Y. and S.S. Kim: Internet Users' Information Privacy-Protective Responses: A Taxonomy and a Nomological Model. MIS Quarterly, 2008. 32(3): p. 503-529.

[26] Avizienis, A., J.-C. Laprie, and B. Randell: Fundamental Concepts of Computer System Dependability, in IARP/IEEE-RAS Workshop on Robot Dependability: Technological Challenge of Dependable Robots in Human Environments. 2001: Seoul, Korea.

[27] Shankar, V., G.L. Urban, and F. Sultan, Online trust: a stakeholder perspective, concepts, implications, and future directions. The Journal of Strategic Information Systems, 2002. 11(3-4): p. 325-344.

[28] McAfee, A.P., Enterprise 2.0: The Dawn of Emergent Collaboration. MIT Sloan Management Review, 2006. 47(3): p. 21-28.

[29] Kramer, J., S. Noronha, and J. Vergo: A user-centered design approach to personalization. Commun. ACM, 2000. 43(8): p. 44-48.

[30] Herrmann, T., G. Kunau, and K.-U. Loser: Sociotechnical Walkthrough - ein methodischer Beitrag zur Gestaltung soziotechnischer Systeme, in Mensch und Computer 2002, M. Herczeg, W. Prinz, and H. Oberquelle, Editors. 2002. p. 323-332.